# ELECTRICAL ENGINEERING POCKET HANDBOOK



*This handbook presented to:*

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# PREFACE

## Engineers Data Handbook Copy

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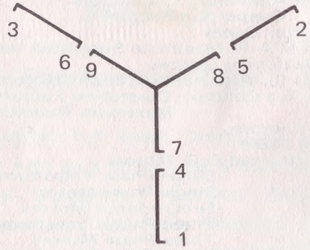
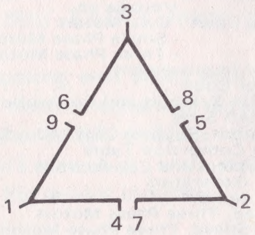
## CONNECTIONS FOR NINE LEAD, THREE PHASE MOTORS

### STAR CONNECTED




| Voltage | Line 1 | Line 2 | Line 3 | Together |
|---|---|---|---|---|
| Low | 1 & 7 | 2 & 8 | 3 & 9 | 4&5&6 |
| High | 1 | 2 | 3 | 4&7,5&8,6&9 |

### DELTA CONNECTED

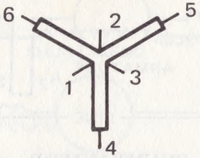



| Voltage | Line 1 | Line 2 | Line 3 | Together |
|---|---|---|---|---|
| Low | 1&6&7 | 2&4&8 | 3&5&9 | None |
| High | 1 | 2 | 3 | 4&7,5&8,6&9 |

## TERMINAL MARKINGS & CONNECTIONS

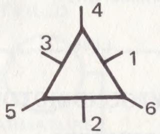
### CONNECTIONS FOR TWO SPEED, THREE PHASE MOTORS

### CONSTANT TORQUE



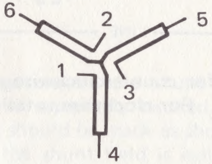

| Speed | Line 1 | Line 2 | Line 3 | |
|---|---|---|---|---|
| High | 4 | 5 | 6 | 1-2-3 Together |
| Low | 2 | 3 | 1 | 4-5-6 Open |

### CONSTANT HORSEPOWER




| Speed | Line 1 | Line 2 | Line 3 | |
|---|---|---|---|---|
| High | 4 | 5 | 6 | 1-2-3 Open |
| Low | 2 | 3 | 1 | 4-5-6 Together |

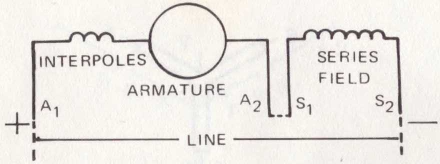
### VARIABLE TORQUE



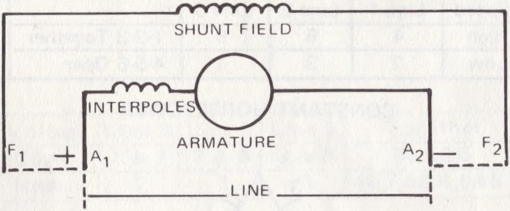

| Speed | Line 1 | Line 2 | Line 3 | |
|---|---|---|---|---|
| High | 4 | 5 | 6 | 1-2-3 Together |
| Low | 2 | 3 | 1 | 4-5-6 Open |

## CONNECTIONS FOR D.C. MOTORS

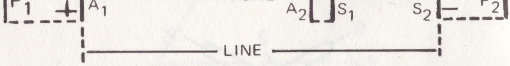
### SERIES MOTOR




### SHUNT MOTOR




### COMPOUND MOTOR



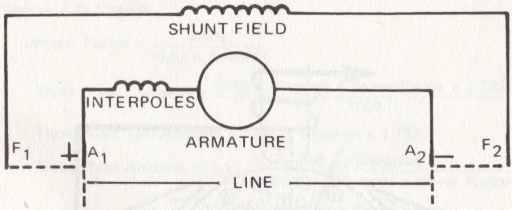

All connections for counterclockwise rotation facing commutator end. For clockwise rotation interchange $A_1$ and $A_2$.

When shunt field is separately excited same polarities must be observed for a given rotation.

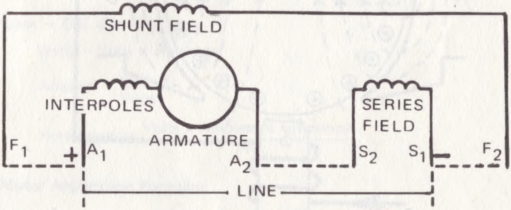
# TERMINAL MARKINGS & CONNECTIONS

## CONNECTIONS FOR D.C. GENERATORS

### SHUNT GENERATOR



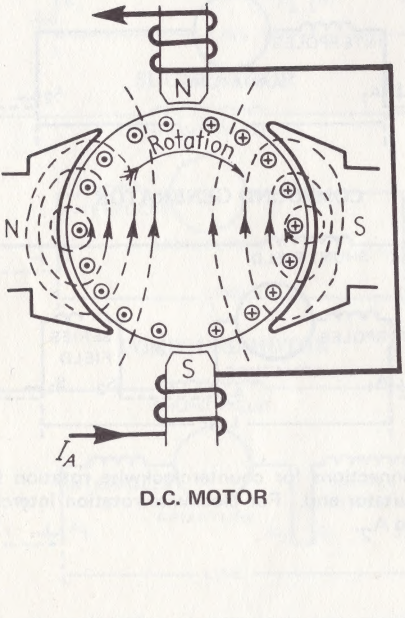

### COMPOUND GENERATOR




All connections for counterclockwise rotation facing commutator end. For clockwise rotation interchange $A_1$ and $A_2$.

For above generators the shunt field may be either self-excited or separately excited. When self-excited, connections should be made as shown. When separately excited, the shunt field is isolated from the other windings. When separately excited same polarities must be observed for given rotation.

# FIELD POLARITY
# D.C. EQUIPMENT




**D.C. MOTOR**

"Diagram shows polarity of interpole with respect to polarity of main field pole for a D.C. motor. For a D.C. generator reverse the direction of rotation.

# MISCELLANEOUS ELECTRICAL FORMULAS

**Ohms Law:**

Ohms = Volts/Amperes

Amperes = Volts/Ohms

Volts = Amperes x Ohms

**Power – A.C. Circuits:**

$$\text{Power Factor} = \frac{\text{Watts}}{\text{Volts} \times \text{Amperes}}$$

$$\text{Three Phase Kilowatts} = \frac{\text{Volts} \times \text{Amperes} \times \text{Power Factor} \times 1.732}{1000}$$

Three Phase Volt-Amperes = Volts x Amperes x 1.732

$$\text{Three Phase Amperes} = \frac{746 \times \text{Horsepower}}{1.732 \times \text{Volts} \times \text{Efficiency} \times \text{Power Factor}}$$

$$\text{Single Phase Kilowatts} = \frac{\text{Volts} \times \text{Amperes} \times \text{Power Factor}}{1000}$$

$$\text{Single Phase Amperes} = \frac{746 \times \text{Horsepower}}{\text{Volts} \times \text{Efficiency} \times \text{Power Factor}}$$

**Power – D.C. Circuits:**

Watts = Volts x Amperes

$$\text{Amperes} = \frac{\text{Watts}}{\text{Volts}}$$

$$\text{Horsepower} = \frac{\text{Volts} \times \text{Amperes} \times \text{Efficiency}}{746}$$

**Motor Application Formulas:**

$$\text{Torque (lb.-ft.)} = \frac{\text{Horsepower} \times 5250}{\text{RPM}}$$

$$\text{Shaft Stress (pds. per sq. inch)} = \frac{\text{HP} \times 321{,}000}{\text{RPM} \times \text{Shaft Diam.}^3}$$

**For Pumps:**

$$\text{Horsepower} = \frac{\text{GPM} \times \text{Head in Feet} \times \text{Specific Gravity}}{3960 \times \text{Efficiency of pump}}$$

**For Fans and Blowers:**

$$\text{Horsepower} = \frac{\text{CFM} \times \text{Pressure (pounds/sq. ft.)}}{33000 \times \text{Efficiency}}$$

**Speed:**

$$\text{Synchronous RPM} = \frac{\text{Hertz} \times 120}{\text{Poles}}$$

$$\text{Percent Slip} = \frac{\text{Synchronous RPM} - \text{Full Load RPM}}{\text{Synchronous RPM}} \times 100$$

# MOTOR FULL LOAD CURRENTS

3 Phase A.C. Induction Type—
Squirrel Cage and Wound Rotor

| HP | 115V | 200V | 230V | 460V | 575V | 2300V | 4160V |
|---|---|---|---|---|---|---|---|
| ½ | 4 | 2.3 | 2 | 1 | .8 | | |
| ¾ | 5.6 | 3.2 | 2.8 | 1.4 | 1.1 | | |
| 1 | 7.2 | 4.15 | 3.6 | 1.8 | 1.4 | | |
| 1½ | 10.4 | 6 | 5.2 | 2.6 | 2.1 | | |
| 2 | 13.6 | 7.8 | 6.8 | 3.4 | 2.7 | | |
| 3 | | 11 | 9.6 | 4.8 | 3.9 | | |
| 5 | | 17.5 | 15.2 | 7.6 | 6.1 | | |
| 7½ | | 25 | 22 | 11 | 9 | | |
| 10 | | 32 | 28 | 14 | 11 | | |
| 15 | | 48 | 42 | 21 | 17 | | |
| 20 | | 62 | 54 | 27 | 22 | | |
| 25 | | 78 | 68 | 34 | 27 | | |
| 30 | | 92 | 80 | 40 | 32 | | |
| 40 | | 120 | 104 | 52 | 41 | | |
| 50 | | 150 | 130 | 65 | 52 | | |
| 60 | | 177 | 154 | 77 | 62 | 16 | 8.9 |
| 75 | | 221 | 192 | 96 | 77 | 20 | 11 |
| 100 | | 285 | 248 | 124 | 99 | 26 | 14.4 |
| 125 | | 358 | 312 | 156 | 125 | 31 | 17 |
| 150 | | 415 | 360 | 180 | 144 | 37 | 20.5 |
| 200 | | 550 | 480 | 240 | 192 | 49 | 27 |
| Over 200HP Approx. Amperes/HP | | 2.75 | 2.40 | 1.20 | .96 | .24 | .133 |

# MOTOR FULL LOAD CURRENTS

| Single Phase | | | Direct Current | | | | |
|---|---|---|---|---|---|---|---|
| HP | 115V | 230V | HP | 120V | 240V | HP | 240V |
| 1/6 | 4.4 | 2.2 | 1/4 | 3.1 | 1.6 | 15 | 55 |
| 1/4 | 5.8 | 2.9 | 1/3 | 4.1 | 2.0 | 20 | 72 |
| 1/3 | 7.2 | 3.6 | 1/2 | 5.4 | 2.7 | 25 | 89 |
| 1/2 | 9.8 | 4.9 | 3/4 | 7.6 | 3.8 | 30 | 106 |
| 3/4 | 13.8 | 6.9 | 1 | 9.5 | 4.7 | 40 | 140 |
| 1 | 16 | 8 | 1 1/2 | 13.2 | 6.6 | 50 | 173 |
| 1 1/2 | 20 | 10 | 2 | 17 | 8.5 | 60 | 206 |
| 2 | 24 | 12 | 3 | 25 | 12.5 | 75 | 255 |
| 3 | 34 | 17 | 5 | 40 | 20 | 100 | 341 |
| 5 | 56 | 28 | 7 1/2 | 58 | 29 | 125 | 425 |
| 7 1/2 | 80 | 40 | 10 | 76 | 38 | 150 | 506 |
| 10 | 100 | 50 | | | | 200 | 675 |
| | | | | | | OVER 200 Approx. Amps/HP 3.4 | |



## THREE PHASE SYNCHRONOUS MOTORS UNITY POWER FACTOR

| HP | 440V | 550V | 2300V | 4160V | HP | 440V | 550V | 2300V | 4160V |
|---|---|---|---|---|---|---|---|---|---|
| 100 | 106 | 85 | 20 | 11.2 | 400 | 420 | 336 | 80.5 | 44.4 |
| 125 | 132 | 106 | 25 | 14.0 | 500 | 525 | 420 | 100 | 55.5 |
| 150 | 158 | 127 | 30 | 16.7 | 600 | 630 | 505 | 120 | 66.5 |
| 200 | 210 | 168 | 40 | 22.2 | 700 | 735 | 588 | 141 | 77.7 |
| 250 | 262 | 210 | 50 | 27.7 | 800 | 840 | 671 | 161 | 88.8 |
| 300 | 315 | 252 | 60 | 33.3 | 900 | 945 | 755 | 181 | 100 |
| 350 | 368 | 295 | 70.5 | 38.9 | 1000 | 1050 | 840 | 192 | 110 |

# MAXIMUM LOCKED ROTOR CURRENTS–

## 3–Phase Motors

### Voltage

| HP | 200 | 220/230 | 440/460 | 550/575 | 2300 | 4160 |
|---|---|---|---|---|---|---|
| 1/2 | 23 | 20 | 10 | 8 | | |
| 3/4 | 29 | 25 | 12.5 | 10 | | |
| 1 | 34.5 | 30 | 15 | 12 | | |
| 1-1/2 | 46 | 40 | 20 | 16 | | |
| 2 | 57.5 | 50 | 25 | 20 | | |
| 3 | 73.5 | 64 | 32 | 25 | | |
| 5 | 106 | 92 | 46 | 37 | | |
| 7-1/2 | 146 | 127 | 63 | 51 | | |
| 10 | 186 | 162 | 81 | 65 | | |
| 15 | 267 | 232 | 116 | 93 | | |
| 20 | 334 | 290 | 145 | 116 | | |
| 25 | 420 | 365 | 182 | 146 | 35 | 19 |
| 30 | 500 | 435 | 217 | 174 | 41 | 23 |
| 40 | 667 | 580 | 290 | 232 | 55 | 30 |
| 50 | 834 | 725 | 362 | 290 | 69 | 38 |
| 60 | 1000 | 870 | 435 | 348 | 83 | 46 |
| 75 | 1250 | 1085 | 592 | 435 | 104 | 57 |
| 100 | 1670 | 1450 | 725 | 580 | 139 | 76 |
| 125 | 2085 | 1815 | 907 | 726 | 173 | 96 |
| 150 | 2500 | 2170 | 1085 | 870 | 208 | 115 |
| 200 | 3340 | 2900 | 1450 | 1160 | 278 | 153 |
| 250 | 4200 | 3650 | 1825 | 1460 | 349 | 193 |
| 300 | 5050 | 4400 | 2200 | 1760 | 420 | 232 |
| 350 | 5860 | 5100 | 2550 | 2040 | 488 | 270 |
| 400 | 6670 | 5800 | 2900 | 2320 | 555 | 306 |
| 450 | 7470 | 6500 | 3250 | 2600 | 620 | 344 |
| 500 | 8340 | 7250 | 3625 | 2900 | 693 | 383 |

Based on NEMA Standards MGI—12.34—June, 1972

## NEMA Code Letters

| NEMA Code Letter | Locked Rotor KVA Per HP | NEMA Code Letter | Locked Rotor KVA Per HP |
|---|---|---|---|
| A | 0 - 3.15 | L | 9.0 - 10.0 |
| B | 3.15 - 3.55 | M | 10.0 - 11.2 |
| C | 3.55 - 4.0 | N | 11.2 - 12.5 |
| D | 4.0 - 4.5 | P | 12.5 - 14.0 |
| E | 4.5 - 5.0 | R | 14.0 - 16.0 |
| F | 5.0 - 5.6 | S | 16.0 - 18.0 |
| G | 5.6 - 6.3 | T | 18.0 - 20.0 |
| H | 6.3 - 7.1 | U | 20.0 - 22.4 |
| J | 7.1 - 8.0 | V | 22.4 and up |
| K | 8.0 - 9.0 | | |

NEMA Standards MG 1-10.36, June, 1972.

$$\text{Start. Kva per Hp} = \frac{\text{Volts x Locked-rotor Amp}}{\text{1000 x Horsepower}} \times \begin{cases} \text{1 for 1-phase} \\ \text{2 for 2-phase} \\ \text{1.732 for 3-ph} \end{cases}$$

## Code Letters Usually Applied to Ratings of Motors Normally Started on Full Voltage

| Code Letters | | F | G | H | J | K | L |
|---|---|---|---|---|---|---|---|
| Horsepower | 3-phase | 15 up | 10-7½ | 5 | 3 | 2-1½ | 1 |
| | 1-phase | — | 5 | 3 | 2-1½ | 1-¾ | ½ |

## NEMA SIZE STARTERS

| NEMA SIZE | MAXIMUM HORSEPOWER — SINGLE PHASE MOTORS FULL VOLTAGE STARTING | |
|---|---|---|
| | 115 V. | 230 V. |
| 00 | 1/3 | 1 |
| 0 | 1 | 2 |
| 1 | 2 | 3 |
| 1½ | 3 | 5 |
| 2 | — | 7½ |
| 3 | — | 15 |

## NEMA SIZE STARTERS

| NEMA SIZE | MAXIMUM HORSEPOWER POLYPHASE MOTORS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FULL VOLTAGE STARTING | | | AUTO TRANSF. STARTING | | | PART WINDING STARTING | | | WYE-DELTA STARTING | | |
| | 200V | 230V | 460V 575V | 200V | 230V | 460V 575V | 200V | 230V | 460V 575V | 200V | 230V | 460V 575V |
| 00 | 1½ | 1½ | 2 | — | — | — | — | — | — | — | — | — |
| 0 | 3 | 3 | 5 | — | — | — | — | — | — | — | — | — |
| 1 | 7½ | 7½ | 10 | 7½ | 7½ | 10 | 10 | 10 | 15 | 10 | 10 | 15 |
| 2 | 10 | 15 | 25 | 10 | 15 | 25 | 20 | 25 | 40 | 20 | 25 | 40 |
| 3 | 25 | 30 | 50 | 25 | 30 | 50 | 40 | 50 | 75 | 40 | 50 | 75 |
| 4 | 40 | 50 | 100 | 40 | 50 | 100 | 75 | 75 | 150 | 60 | 75 | 150 |
| 5 | 75 | 100 | 200 | 75 | 100 | 200 | 150 | 150 | 350 | 150 | 150 | 300 |
| 6 | 150 | 200 | 400 | 150 | 200 | 400 | — | 300 | 600 | 300 | 350 | 700 |
| 7 | — | 300 | 600 | — | 300 | 600 | — | 450 | 900 | 500 | 500 | 1000 |
| 8 | — | 450 | 900 | — | 450 | 900 | — | 700 | 1400 | 750 | 800 | 1500 |
| 9 | — | 800 | 1600 | — | 800 | 1600 | — | 1300 | 2600 | 1500 | 1500 | 3000 |

## COMPARISION OF METHODS OF STARTING SQUIRREL CAGE INDUCTION MOTORS

| Starter Type | % Full-Voltage Value | | |
|---|---|---|---|
| | Voltage at Motor | Line Current | Motor Output Torque |
| Full Voltage | 100 | 100 | 100 |
| Autotransformer | | | |
| 80 pc tap | 80 | 64* | 64 |
| 65 pc tap | 65 | 42* | 42 |
| 50 pc tap | 50 | 25* | 25 |
| Primary-reactor | | | |
| 80 pc tap | 80 | 80 | 64 |
| 65 pc tap | 65 | 65 | 42 |
| 50 pc tap | 50 | 50 | 25 |
| Primary-resistor | | | |
| Typical rating | 80 | 80 | 64 |
| Part-winding | | | |
| Low-speed motors (1/2-1/2) | 100 | 50 | 50 |
| High-speed motors (1/2-1/2) | 100 | 70 | 50 |
| High-speed motors (2/3-1/3) | 100 | 65 | 42 |
| Wye Start-Delta Run (1/3-1/3) | 100 | 33 | 33 |

*Autotransformer magnetizing current not included. Magnetizing current usually less than 25 percent motor full-load current.

# THREE PHASE FRAME SIZES

| RPM | 3600 | | | 1800 | | |
|---|---|---|---|---|---|---|
| NEMA | | 1952 | 1964 | | 1952 | 1964 |
| Program | Orig. | Rerate | Rerate | Orig. | Rerate | Rerate |
| HP | | | | | | |
| 1 | ------ | -------- | -------- | 203 | 182 | 143T |
| 1½ | 203 | 182 | 143T | 204 | 184 | 145T |
| 2 | 204 | 184 | 145T | 224 | 184 | 145T |
| 3 | 224 | 184 | 145T | 225 | 213 | 182T |
| 5 | 225 | 213 | 182T | 254 | 215 | 184T |
| 7½ | 254 | 215 | 184T | 284 | 254U | 213T |
| 10 | 284 | 254U | 213T | 324 | 256U | 215T |
| 15 | 324 | 256U | 215T | 326 | 284U | 254T |
| 20 | 326 | 284U | 254T | 364 | 286U | 256T |
| 25 | 364S | 286U | 256T | 364 | 324U | 284T |
| 30 | 364S | 324S | 284TS | 365 | 326U | 286T |
| 40 | 365S | 326S | 286TS | 404 | 364U | 324T |
| 50 | 404S | 364US | 324TS | 405S | 365US | 326T |
| 60 | 405S | 365US | 326TS | 444S | 404US | 364TS |
| 75 | 444S | 404US | 364TS | 445S | 405US | 365TS |
| 100 | 445S | 405US | 365TS | 504S | 444US | 404TS |
| 125 | 504S | 444US | 404TS | 505S | 445US | 405TS |
| 150 | 505S | 445US | 405TS | -------- | -------- | 444TS |
| 200 | -------- | -------- | 444TS | -------- | -------- | 445TS |
| 250 | -------- | -------- | 445TS | -------- | -------- | -------- |

## OPEN MOTORS–GENERAL PURPOSE

| 1200 | | | 900 | | |
|---|---|---|---|---|---|
| | 1952 | 1964 | | 1952 | 1964 |
| Orig. | Rerate | Rerate | Orig. | Rerate | Rerate |
| 204 | 184 | 145T | 225 | 213 | 182T |
| 224 | 184 | 182T | 254 | 213 | 184T |
| 225 | 213 | 184T | 254 | 215 | 213T |
| 254 | 215 | 213T | 284 | 254U | 215T |
| 284 | 254U | 215T | 324 | 256U | 254T |
| 324 | 256U | 254T | 326 | 284U | 256T |
| 326 | 284U | 256T | 364 | 286U | 284T |
| 364 | 324U | 284T | 365 | 326U | 286T |
| 365 | 326U | 286T | 404 | 364U | 324T |
| 404 | 364U | 324T | 405 | 365U | 326T |
| 405 | 365U | 326T | 444 | 404U | 364T |
| 444 | 404U | 364T | 445 | 405U | 365T |
| 445 | 405U | 365T | 504U | 444U | 404T |
| 504U | 444U | 404T | 505 | 445U | 405T |
| 505 | 445U | 405T | -------- | -------- | 444T |
| -------- | -------- | 444T | -------- | -------- | 445T |
| -------- | -------- | 445T | -------- | -------- | -------- |
| -------- | -------- | -------- | -------- | -------- | -------- |
| -------- | -------- | -------- | -------- | -------- | -------- |
| -------- | -------- | -------- | -------- | -------- | -------- |

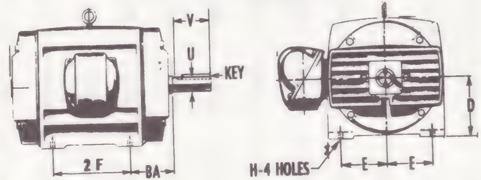
# THREE PHASE FRAME SIZES

| RPM | 3600 | | | 1800 | | |
|---|---|---|---|---|---|---|
| NEMA | | 1952 | 1964 | | 1952 | 1964 |
| Program HP | Orig. | Rerate | Rerate | Orig. | Rerate | Rerate |
| 1 | -------- | -------- | -------- | 203 | 182 | 143T |
| 1½ | 203 | 182 | 143T | 204 | 184 | 145T |
| 2 | 204 | 184 | 145T | 224 | 184 | 145T |
| 3 | 224 | 184 | 182T | 225 | 213 | 182T |
| 5 | 225 | 213 | 184T | 254 | 215 | 184T |
| 7½ | 254 | 215 | 213T | 284 | 254U | 213T |
| 10 | 284 | 254U | 215T | 324 | 256U | 215T |
| 15 | 324 | 256U | 254T | 326 | 284U | 254T |
| 20 | 326 | 286U | 256T | 364 | 286U | 256T |
| 25 | 365S | 324U | 284TS | 365 | 324U | 284T |
| 30 | 404S | 326S | 286TS | 404 | 326U | 286T |
| 40 | 405S | 364US | 324TS | 405 | 364U | 324T |
| 50 | 444S | 365US | 326TS | 444S | 365US | 326T |
| 60 | 445S | 405US | 364TS | 445S | 405US | 364TS |
| 75 | 504S | 444US | 365TS | 504S | 444US | 365TS |
| 100 | 505S | 445US | 405TS | 505S | 445US | 405TS |
| 125 | -------- | -------- | 444TS | -------- | -------- | 444TS |
| 150 | -------- | -------- | 445TS | -------- | -------- | 445TS |

# TEFC—GENERAL PURPOSE

| 1200 | | | 900 | | |
|---|---|---|---|---|---|
| | 1952 | 1964 | | 1952 | 1964 |
| Orig. | Rerate | Rerate | Orig. | Rerate | Rerate |
| 204 | 184 | 145T | 225 | 213 | 182T |
| 224 | 184 | 182T | 254 | 213 | 184T |
| 225 | 213 | 184T | 254 | 215 | 213T |
| 254 | 215 | 213T | 284 | 254U | 215T |
| 284 | 254U | 215T | 324 | 256U | 254T |
| 324 | 256U | 254T | 326 | 284U | 256T |
| 326 | 284U | 256T | 364 | 286U | 284T |
| 364 | 324U | 284T | 365 | 326U | 286T |
| 365 | 326U | 286T | 404 | 364U | 324T |
| 404 | 364U | 324T | 405 | 365U | 326T |
| 405 | 365U | 326T | 444 | 404U | 364T |
| 444 | 404U | 364T | 445 | 405U | 365T |
| 445 | 405U | 365T | 504U | 444U | 404T |
| 504U | 444U | 404T | 505 | 445U | 405T |
| 505 | 445U | 405T | -------- | -------- | 444T |
| -------- | -------- | 444T | -------- | -------- | 445T |
| -------- | -------- | 445T | -------- | -------- | -------- |
| -------- | -------- | -------- | -------- | -------- | -------- |

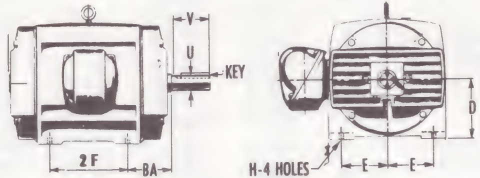
## FRAME DIMENSIONS




| Frame | D | E | 2F | H | U | BA | V min. | KEY WIDTH | KEY THICK. | KEY LENG. |
|---|---|---|---|---|---|---|---|---|---|---|
| 48 | 3 | 2-1/8 | 2-3/4 | 11/32 | 1/2 | 2-1/2 | | | 3/64 Flat | |
| 56 | 3-1/2 | 2-7/16 | 3 | 11/32 | 5/8 | 2-3/4 | | 3/16 | 3/16 | 1-3/8 |
| 143 | 3-1/2 | 2-3/4 | 4 | 11/32 | 3/4 | 2-1/4 | 1-3/4 | 3/16 | 3/16 | 1-3/8 |
| 143T | 3-1/2 | 2-3/4 | 4 | 11/32 | 7/8 | 2-1/4 | 2 | 3/16 | 3/16 | 1-3/8 |
| 145 | 3-1/2 | 2-3/4 | 5 | 11/32 | 3/4 | 2-1/4 | 1-3/4 | 3/16 | 3/16 | 1-3/8 |
| 145T | 3-1/2 | 2-3/4 | 5 | 11/32 | 7/8 | 2-1/4 | 2 | 3/16 | 3/16 | 1-3/8 |
| 182 | 4-1/2 | 3-3/4 | 4-1/2 | 13/32 | 7/8 | 2-3/4 | 2 | 3/16 | 3/16 | 1-3/8 |
| 182T | 4-1/2 | 3-3/4 | 4-1/2 | 13/32 | 1-1/8 | 2-3/4 | 2-1/2 | 1/4 | 1/4 | 1-3/4 |
| 184 | 4-1/2 | 3-3/4 | 5-1/2 | 13/32 | 7/8 | 2-3/4 | 2 | 3/16 | 3/16 | 1-3/8 |
| 184T | 4-1/2 | 3-3/4 | 5-1/2 | 13/32 | 1-1/8 | 2-3/4 | 2-1/2 | 1/4 | 1/4 | 1-3/4 |
| 203 | 5 | 4 | 5-1/2 | 13/32 | 3/4 | 3-1/8 | 2 | 3/16 | 3/16 | 1-1/2 |
| 204 | 5 | 4 | 6-1/2 | 13/32 | 3/4 | 3-1/8 | 2 | 3/16 | 3/16 | 1-1/2 |
| 213 | 5-1/4 | 4-1/4 | 5-1/2 | 13/32 | 1-1/8 | 3-1/2 | 2-3/4 | 1/4 | 1/4 | 2 |
| 213T | 5-1/4 | 4-1/4 | 5-1/2 | 13/32 | 1-3/8 | 3-1/2 | 3-1/8 | 5/16 | 5/16 | 2-3/8 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 215 | 5-1/4 | 4-1/4 | 7 | 13/32 | 1-1/8 | 3-1/2 | 2-3/4 | 1/4 | 1/4 | 2 |
| 215T | 5-1/4 | 4-1/4 | 7 | 13/32 | 1-3/8 | 3-1/2 | 3-1/8 | 5/16 | 5/16 | 2-3/8 |
| 224 | 5-1/2 | 4-1/2 | 6-3/4 | 13/32 | 1 | 3-1/2 | 2-3/4 | 1/4 | 1/4 | 2 |
| 225 | 5-1/2 | 4-1/2 | 7-1/2 | 13/32 | 1 | 3-1/2 | 2-3/4 | 1/4 | 1/4 | 2 |
| 254 | 6-1/4 | 5 | 8-1/4 | 17/32 | 1-1/8 | 4-1/4 | 3-1/8 | 1/4 | 1/4 | 2 |
| 254U | 6-1/4 | 5 | 8-1/4 | 17/32 | 1-3/8 | 4-1/4 | 3-1/2 | 5/16 | 5/16 | 2-3/4 |
| 254T | 6-1/4 | 5 | 8-1/4 | 17/32 | 1-5/8 | 4-1/4 | 3-3/4 | 3/8 | 3/8 | 2-7/8 |
| 256U | 6-1/4 | 5 | 10 | 17/32 | 1-3/8 | 4-1/4 | 3-1/2 | 5/16 | 5/16 | 2-3/4 |
| 256T | 6-1/4 | 5 | 10 | 17/32 | 1-5/8 | 4-1/4 | 3-3/4 | 3/8 | 3/8 | 2-7/8 |
| 284 | 7 | 5-1/2 | 9-1/2 | 17/32 | 1-1/4 | 4-3/4 | 3-1/2 | 1/4 | 1/4 | 2 |
| 284U | 7 | 5-1/2 | 9-1/2 | 17/32 | 1-5/8 | 4-3/4 | 4-5/8 | 3/8 | 3/8 | 3-3/4 |
| 284T | 7 | 5-1/2 | 9-1/2 | 17/32 | 1-7/8 | 4-3/4 | 4-3/8 | 1/2 | 1/2 | 3-1/4 |
| 284TS | 7 | 5-1/2 | 9-1/2 | 17/32 | 1-5/8 | 4-3/4 | 3 | 3/8 | 3/8 | 1-7/8 |
| 286U | 7 | 5-1/2 | 11 | 17/32 | 1-5/8 | 4-3/4 | 4-5/8 | 3/8 | 3/8 | 3-3/4 |
| 286T | 7 | 5-1/2 | 11 | 17/32 | 1-7/8 | 4-3/4 | 4-3/8 | 1/2 | 1/2 | 3-1/4 |
| 286TS | 7 | 5-1/2 | 11 | 17/32 | 1-5/8 | 4-3/4 | 3 | 3/8 | 3/8 | 1-7/8 |
| 324 | 8 | 6-1/4 | 10-1/2 | 21/32 | 1-5/8 | 5-1/4 | 4-5/8 | 3/8 | 3/8 | 3-3/4 |
| 324U | 8 | 6-1/4 | 10-1/2 | 21/32 | 1-7/8 | 5-1/4 | 5-3/8 | 1/2 | 1/2 | 4-1/4 |
| 324S | 8 | 6-1/4 | 10-1/2 | 21/32 | 1-5/8 | 5-1/4 | 3 | 3/8 | 3/8 | 1-7/8 |
| 324T | 8 | 6-1/4 | 10-1/2 | 21/32 | 2-1/8 | 5-1/4 | 5 | 1/2 | 1/2 | 3-7/8 |
| 324TS | 8 | 6-1/4 | 10-1/2 | 21/32 | 1-7/8 | 5-1/4 | 3-1/2 | 1/2 | 1/2 | 2 |
| 326 | 8 | 6-1/4 | 12 | 21/32 | 1-5/8 | 5-1/4 | 4-5/8 | 3/8 | 3/8 | 3-3/4 |
| 326U | 8 | 6-1/4 | 12 | 21/32 | 1-7/8 | 5-1/4 | 5-3/8 | 1/2 | 1/2 | 4-1/4 |
| 326S | 8 | 6-1/4 | 12 | 21/32 | 1-5/8 | 5-1/4 | 3 | 3/8 | 3/8 | 1-7/8 |
| 326T | 8 | 6-1/4 | 12 | 21/32 | 2-1/8 | 5-1/4 | 5 | 1/2 | 1/2 | 3-7/8 |
| 326TS | 8 | 6-1/4 | 12 | 21/32 | 1-7/8 | 5-1/4 | 3-1/2 | 1/2 | 1/2 | 2 |

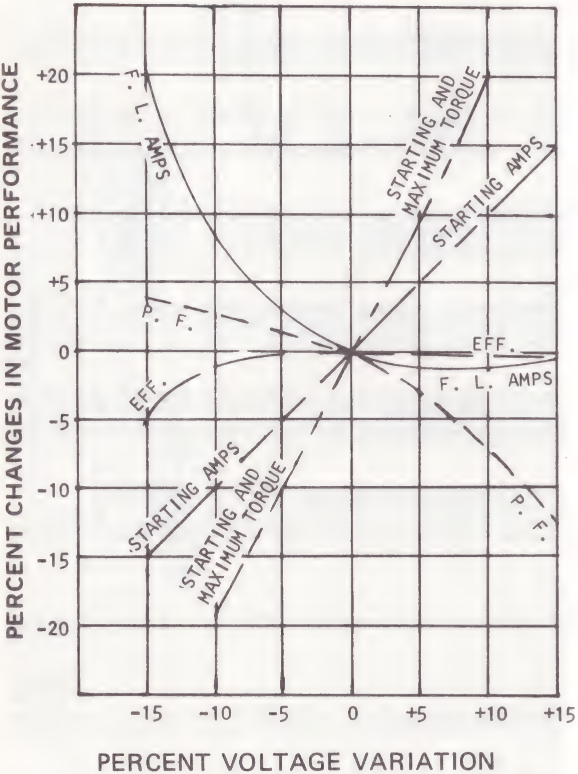
# FRAME DIMENSIONS



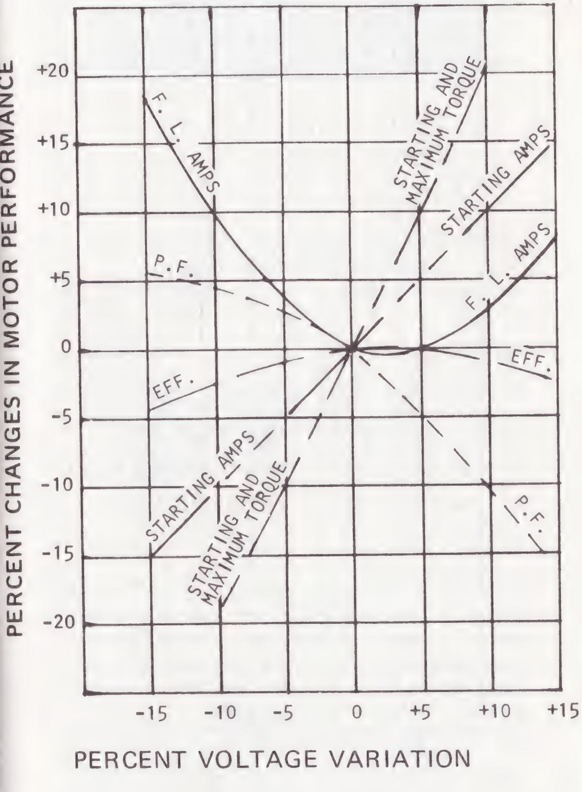

| Frame | D | E | 2F | H | U | BA | V min. | KEY WIDTH | KEY THICK. | KEY LENG. |
|---|---|---|---|---|---|---|---|---|---|---|
| 364 | 9 | 7 | 11-1/4 | 21/32 | 1-7/8 | 5-7/8 | 5-3/8 | 1/2 | 1/2 | 4-1/4 |
| 364S | 9 | 7 | 11-1/4 | 21/32 | 1-5/8 | 5-7/8 | 3 | 3/8 | 3/8 | 1-7/8 |
| 364U | 9 | 7 | 11-1/4 | 21/32 | 2-1/8 | 5-7/8 | 6-1/8 | 1/2 | 1/2 | 5 |
| 364US | 9 | 7 | 11-1/4 | 21/32 | 1-7/8 | 5-7/8 | 3-1/2 | 1/2 | 1/2 | 2 |
| 364T | 9 | 7 | 11-1/4 | 21/32 | 2-3/8 | 5-7/8 | 5-5/8 | 5/8 | 5/8 | 4-1/4 |
| 364TS | 9 | 7 | 11-1/4 | 21/32 | 1-7/8 | 5-7/8 | 3-1/2 | 1/2 | 1/2 | 2 |
| 365 | 9 | 7 | 12-1/4 | 21/32 | 1-7/8 | 5-7/8 | 5-3/8 | 1/2 | 1/2 | 4-1/4 |
| 365S | 9 | 7 | 12-1/4 | 21/32 | 1-5/8 | 5-7/8 | 3 | 3/8 | 3/8 | 1-7/8 |
| 365U | 9 | 7 | 12-1/4 | 21/32 | 2-1/8 | 5-7/8 | 6-1/8 | 1/2 | 1/2 | 5 |
| 365US | 9 | 7 | 12-1/4 | 21/32 | 1-7/8 | 5-7/8 | 3-1/2 | 1/2 | 1/2 | 2 |
| 365T | 9 | 7 | 12-1/4 | 21/32 | 2-3/8 | 5-7/8 | 5-5/8 | 5/8 | 5/8 | 4-1/4 |
| 365TS | 9 | 7 | 12-1/4 | 21/32 | 1-7/8 | 5-7/8 | 3-1/2 | 1/2 | 1/2 | 2 |
| 404 | 10 | 8 | 12-1/4 | 13/16 | 2-1/8 | 6-5/8 | 6-1/8 | 1/2 | 1/2 | 5 |
| 404S | 10 | 8 | 12-1/4 | 13/16 | 1-7/8 | 6-5/8 | 3-1/2 | 1/2 | 1/2 | 2 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 404U | 10 | 8 | 12-1/4 | 13/16 | 2-3/8 | 6-5/8 | 6-7/8 | 5/8 | 5/8 | 5-1/2 |
| 404US | 10 | 8 | 12-1/4 | 13/16 | 2-1/8 | 6-5/8 | 4 | 1/2 | 1/2 | 2-3/4 |
| 404T | 10 | 8 | 12-1/4 | 13/16 | 2-7/8 | 6-5/8 | 7 | 3/4 | 3/4 | 5-5/8 |
| 404TS | 10 | 8 | 12-1/4 | 13/16 | 2-1/8 | 6-5/8 | 4 | 1/2 | 1/2 | 2-3/4 |
| 405 | 10 | 8 | 13-3/4 | 13/16 | 2-1/8 | 6-5/8 | 6-1/8 | 1/2 | 1/2 | 5 |
| 405S | 10 | 8 | 13-3/4 | 13/16 | 1-7/8 | 6-5/8 | 3-1/2 | 1/2 | 1/2 | 2 |
| 405U | 10 | 8 | 13-3/4 | 13/16 | 2-3/8 | 6-5/8 | 6-7/8 | 5/8 | 5/8 | 5-1/2 |
| 405US | 10 | 8 | 13-3/4 | 13/16 | 2-1/8 | 6-5/8 | 4 | 1/2 | 1/2 | 2-3/4 |
| 405T | 10 | 8 | 13-3/4 | 13/16 | 2-7/8 | 6-5/8 | 7 | 3/4 | 3/4 | 5-5/8 |
| 405TS | 10 | 8 | 13-3/4 | 13/16 | 2-1/8 | 6-5/8 | 4 | 1/2 | 1/2 | 2-3/4 |
| 444 | 11 | 9 | 14-1/2 | 13/16 | 2-3/8 | 7-1/2 | 6-7/8 | 5/8 | 5/8 | 5-1/2 |
| 444S | 11 | 9 | 14-1/2 | 13/16 | 2-1/8 | 7-1/2 | 4 | 1/2 | 1/2 | 2-3/4 |
| 444U | 11 | 9 | 14-1/2 | 13/16 | 2-7/8 | 7-1/2 | 8-3/8 | 3/4 | 3/4 | 7 |
| 444US | 11 | 9 | 14-1/2 | 13/16 | 2-1/8 | 7-1/2 | 4 | 1/2 | 1/2 | 2-3/4 |
| 444T | 11 | 9 | 14-1/2 | 13/16 | 3-3/8 | 7-1/2 | 8-1/4 | 7/8 | 7/8 | 6-7/8 |
| 444TS | 11 | 9 | 14-1/2 | 13/16 | 2-3/8 | 7-1/2 | 4-1/2 | 5/8 | 5/8 | 3 |
| 445 | 11 | 9 | 16-1/2 | 13/16 | 2-3/8 | 7-1/2 | 6-7/8 | 5/8 | 5/8 | 5-1/2 |
| 445S | 11 | 9 | 16-1/2 | 13/16 | 2-1/8 | 7-1/2 | 4 | 1/2 | 1/2 | 2-3/4 |
| 445U | 11 | 9 | 16-1/2 | 13/16 | 2-7/8 | 7-1/2 | 8-3/8 | 3/4 | 3/4 | 7 |
| 445US | 11 | 9 | 16-1/2 | 13/16 | 2-1/8 | 7-1/2 | 4 | 1/2 | 1/2 | 2-3/4 |
| 445T | 11 | 9 | 16-1/2 | 13/16 | 3-3/8 | 7-1/2 | 8-1/4 | 7/8 | 7/8 | 6-7/8 |
| 445TS | 11 | 9 | 16-1/2 | 13/16 | 2-3/8 | 7-1/2 | 4-1/2 | 5/8 | 5/8 | 3 |
| 504U | 12-1/2 | 10 | 16 | 15/16 | 2-7/8 | 8-1/2 | 8-3/8 | 3/4 | 3/4 | 7-1/4 |
| 504S | 12-1/2 | 10 | 16 | 15/16 | 2-1/8 | 8-1/2 | 4 | 1/2 | 1/2 | 2-3/4 |
| 505 | 12-1/2 | 10 | 18 | 15/16 | 2-7/8 | 8-1/2 | 8-3/8 | 3/4 | 3/4 | 7-1/4 |
| 505S | 12-1/2 | 10 | 18 | 15/16 | 2-1/8 | 8-1/2 | 4 | 1/2 | 1/2 | 2-3/4 |

## EFFECT OF VOLTAGE VARIATION ON "U" FRAME MOTORS



# EFFECT OF VOLTAGE VARIATION ON "T" FRAME MOTORS



# MOTOR WIRING

## 3 Phase, Squirrel Cage Induction Motors

| | 230 Volts | | | | | | 460 Volts | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HORSEPOWER | APPROX. FULL-LOAD AMPS | COPPER * WIRE SIZE MIN AWG | | CONDUIT ** SIZE INCHES | | BRANCH CIRCUIT FUSE, AMPS † | APPROX. FULL-LOAD AMPS | COPPER * WIRE SIZE MIN AWG | | CONDUIT ** SIZE INCHES | | BRANCH CIRCUIT FUSE, AMPS † |
| | | R,T | RH | R,T | RH | | | R,T | RH | R,T | RH | |
| 1 | 3.6 | 14 | 14 | ½ | ½ | 15 | 1.8 | 14 | 14 | ½ | ½ | 15 |
| 1½ | 5.2 | 14 | 14 | ½ | ½ | 15 | 2.6 | 14 | 14 | ½ | ½ | 15 |
| 2 | 6.8 | 14 | 14 | ½ | ½ | 25 | 3.4 | 14 | 14 | ½ | ½ | 15 |
| 3 | 9.6 | 14 | 14 | ½ | ½ | 30 | 4.8 | 14 | 14 | ½ | ½ | 15 |
| 5 | 15.2 | 12 | 12 | ½ | ½ | 50 | 7.6 | 14 | 14 | ½ | ½ | 25 |
| 7½ | 22 | 10 | 10 | ¾ | ¾ | 70 | 11 | 14 | 14 | ½ | ½ | 35 |
| 10 | 28 | 8 | 8 | ¾ | ¾ | 90 | 14 | 12 | 12 | ½ | ½ | 45 |
| 15 | 42 | 6 | 6 | 1 | 1 | 125 | 21 | 10 | 10 | ¾ | ¾ | 70 |
| 20 | 54 | 4 | 6 | 1¼ | 1 | 175 | 27 | 8 | 8 | ¾ | ¾ | 90 |
| 25 | 68 | 2 | 4 | 1¼ | 1¼ | 225 | 34 | 6 | 8 | 1 | ¾ | 110 |
| 30 | 80 | 1 | 3 | 1½ | 1¼ | 250 | 40 | 6 | 6 | 1 | 1 | 125 |
| 40 | 104 | 2/0 | 1 | 2 | 1½ | 350 | 52 | 4 | 6 | 1¼ | 1 | 175 |
| 50 | 130 | 3/0 | 2/0 | 2 | 2 | 400 | 65 | 2 | 4 | 1¼ | 1¼ | 200 |
| 60 | 154 | 4/0 | 3/0 | 2½ | 2 | 500 | 77 | 1 | 3 | 1½ | 1¼ | 250 |

*The values given are for not more than three conductors in a raceway or cable, and having 60°C insulations, types RU, RUW, T, and TW; or 75°C insulations, types RH and RHW. For other conditions and insulations see the National Electrical Code.

**Conduit size refers to three conductors in one conduit.

†The values given are for branch-circuit protection using fuses and full-voltage starting. For circuit breaker ratings, reduced-voltage starting, and motor overload protection, see National Electrical Code.

## MOTOR WIRING – Continued

### Single Phase Induction Motors

| | 115 Volts | | | | | | 230 Volts | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HORSEPOWER | APPROX. FULL-LOAD AMPS | COPPER* WIRE SIZE MIN AWG R,T | RH | CONDUIT** SIZE INCHES R,T | RH | BRANCH CIRCUIT FUSE, AMPS † | APPROX. FULL-LOAD AMPS | COPPER* WIRE SIZE MIN AWG R,T | RH | CONDUIT** SIZE INCHES R,T | RH | BRANCH CIRCUIT FUSE, AMPS † |
| ½ | 9.8 | 14 | 14 | ½ | ½ | 30 | 4.9 | 14 | 14 | ½ | ½ | 15 |
| ¾ | 13.8 | 12 | 12 | ½ | ½ | 45 | 6.9 | 14 | 14 | ½ | ½ | 25 |
| 1 | 16 | 12 | 12 | ½ | ½ | 50 | 8 | 14 | 14 | ½ | ½ | 25 |
| 1½ | 20 | 10 | 10 | ¾ | ¾ | 60 | 10 | 14 | 14 | ½ | ½ | 30 |
| 2 | 24 | 10 | 10 | ¾ | ¾ | 80 | 12 | 14 | 14 | ½ | ½ | 40 |
| 3 | 34 | 6 | 8 | 1 | ¾ | 110 | 17 | 10 | 10 | ¾ | ¾ | 60 |
| 5 | — | — | — | — | — | — | 28 | 8 | 8 | ¾ | ¾ | 90 |

### DIRECT CURRENT MOTORS

| | 120 Volts | | | | | | 240 Volts | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HORSEPOWER | APPROX. FULL-LOAD AMPS | COPPER* WIRE SIZE MIN AWG R,T | RH | CONDUIT** SIZE INCHES R,T | RH | BRANCH CIRCUIT FUSE, AMPS † | APPROX. FULL-LOAD AMPS | COPPER* WIRE SIZE MIN AWG R,T | RH | CONDUIT** SIZE INCHES R,T | RH | BRANCH CIRCUIT FUSE, AMPS † |
| 1 | 9.4 | 14 | 14 | ½ | ½ | 15 | 4.7 | 14 | 14 | ½ | ½ | 15 |
| 1½ | 13.2 | 12 | 12 | ½ | ½ | 25 | 6.6 | 14 | 14 | ½ | ½ | 15 |
| 2 | 17 | 10 | 10 | ¾ | ¾ | 30 | 8.5 | 14 | 14 | ½ | ½ | 15 |
| 3 | 25 | 8 | 8 | ¾ | ¾ | 40 | 12.2 | 12 | 12 | ½ | ½ | 20 |
| 5 | 40 | 6 | 6 | 1 | 1 | 60 | 20 | 10 | 10 | ¾ | ¾ | 30 |
| 7½ | 58 | 3 | 4 | 1¼ | 1¼ | 90 | 29 | 8 | 8 | ¾ | ¾ | 45 |
| 10 | 76 | 2 | 3 | 1¼ | 1¼ | 125 | 38 | 6 | 6 | 1 | 1 | 60 |
| 15 | 110 | 2/0 | 0 | 2 | 1½ | 175 | 55 | 4 | 4 | 1¼ | 1¼ | 90 |
| 20 | 144 | 4/0 | 3/0 | 2 | 2 | 225 | 72 | 2 | 3 | 1¼ | 1¼ | 110 |

*See note preceding page.

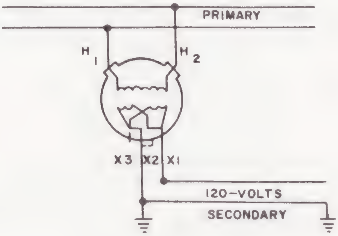
**Conduit size for single phase and direct current motors refers to two conductors in one conduit.

†The values given are for branch circuit protection using fuses and full voltage starting. For circuit breaker ratings, reduced voltage starting, and motor overload protection, see National Electrical Code.

## Maximum Rating or Setting of Motor Branch-Circuit Protective Devices

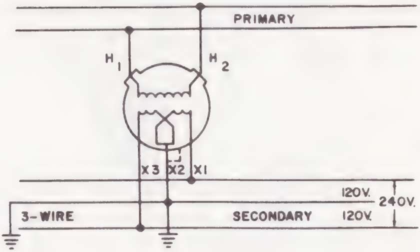
| Type of Motor | Percent of Full Load Current | | | |
|---|---|---|---|---|
| | Nontime Delay Fuse | Dual-Element (Time-Delay) Fuse | Instant. Trip Type Breaker | Time-Limit Breaker |
| All A.C. single-phase and polyphase squirrel-cage and synchronous motors with full-voltage, resistance or reactor starting: | | | | |
| No code letter | 300 | 175 | 700 | 250 |
| Code letter F to V | 300 | 175 | 700 | 250 |
| Code letter B to E | 250 | 175 | 700 | 200 |
| Code letter A | 150 | 150 | 700 | 150 |
| All A.C. squirrel-cage and synchronous motors with auto-transformer starting: | | | | |
| Code letter F to V | 250 | 175 | 700 | 200 |
| Code letter B to E | 200 | 175 | 700 | 200 |
| Code letter A | 150 | 150 | 700 | 150 |
| Wound Rotor | 150 | 150 | 700 | 150 |
| Direct Current | | | | |
| Not more than 50 HP | 150 | 150 | 250 | 150 |
| More than 50 HP | 150 | 150 | 175 | 150 |

# TRANSFORMER CONNECTIONS



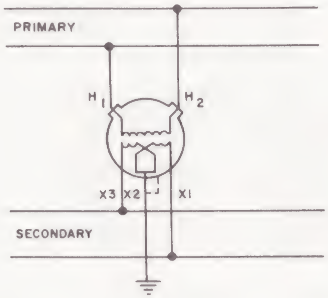

SINGLE-PHASE TO SUPPLY 120-VOLT LIGHTING LOAD

The transformer is connected between high voltage line and load with the 120/240-volt winding connected in parallel. This connection is used where the load is comparatively small and the length of the secondary circuit is short. It is often used for a single customer.



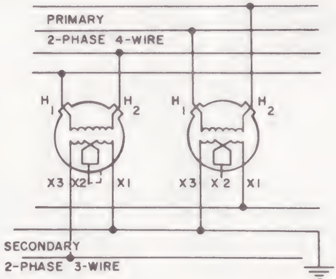

SINGLE-PHASE TO SUPPLY 120/240 – 3-WIRE LIGHTING AND POWER LOAD

Here the 120/240-volt winding is connected in series and the mid-point brought out, making it possible to serve both 120 and 240-volt loads simultaneously. This connection is used in most urban distribution circuits.




SINGLE PHASE FOR POWER

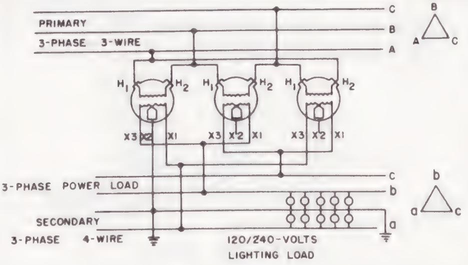
In this case the 120/240-volt winding is connected in series serving 240 volts on a two-wire system. This connection is used for small industrial applications.




TWO-PHASE CONNECTIONS

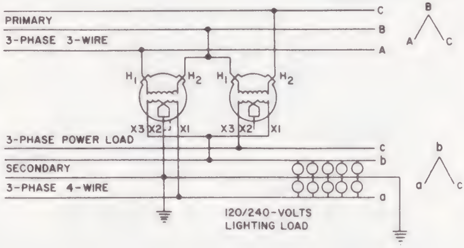
This connection consists merely of two single-phase transformers operated 90° out of phase. For a three-wire secondary as shown, the common wire must carry $\sqrt{2}$ times the load current. In some cases, a four-wire or a five-wire secondary may be used.

# TRANSFORMER CONNECTIONS



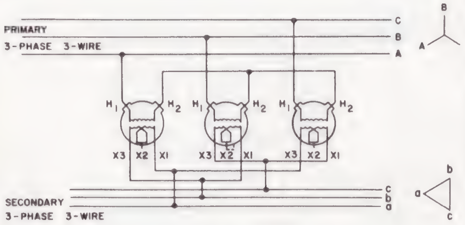

## DELTA-DELTA FOR POWER AND LIGHTING

This connection is often used to supply a small single-phase lighting load and three-phase power load simultaneously. As shown in diagram, the mid-tap of the secondary of one transformer is grounded. Thus, the small lighting load is connected across the transformer with the mid-tap and the ground wire common to both 120 volt circuits. The single-phase lighting load reduces the available three-phase capacity. This connection requires special watt-hour metering.



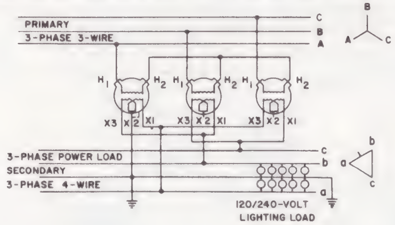

## OPEN-DELTA FOR LIGHTING AND POWER

Where the secondary load is a combination of lighting and power the open-delta connected bank is frequently used. This connection is used when the single-phase lighting load is large as compared with the power load. Here two different size transformers may be used with the lighting load connected across the larger rated unit.



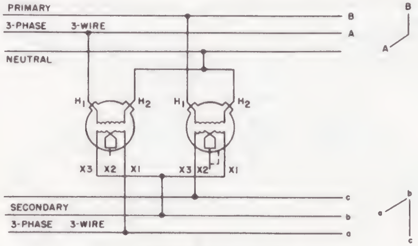

## Y-DELTA FOR POWER

Often it is desirable to increase the voltage of a circuit from 2400 to 4160 volts to increase its potential capacity. This diagram shows such a system after it has been changed to 4160 volts. The previously delta connected distribution transformer primaries are now connected from line to neutral so that no major change in equipment is necessary. The primary neutral should not be grounded or tied into the system neutral since a single-phase ground fault may result in extensive blowing of fuses throughout the system.



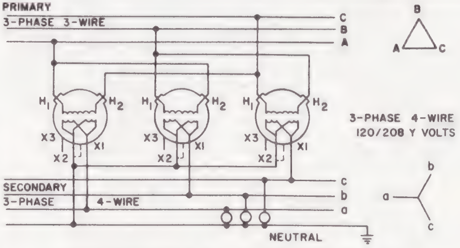

## Y-DELTA FOR LIGHTING AND POWER

This diagram shows the connections for the Y-delta bank to supply both light and power. This connection is similar to the delta-delta bank with only the primary connections changed. The primary neutral should not be grounded or tied into the system neutral, since a single-phase ground fault may result in extensive blowing of fuses throughout the system. The single-phase load reduces the available three-phase capacity. This connection requires special watt-hour metering.




OPEN Y-DELTA

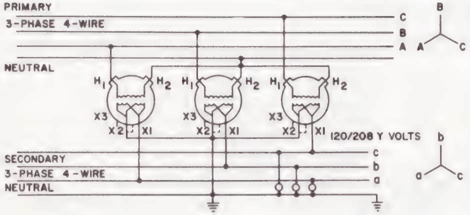
When operating Y-delta and one phase is disabled, service may be maintained at reduced load as shown. The neutral in this case must be connected to the neutral of the stepup bank through a copper conductor. The system is unbalanced, electro-statically and electro-magnetically, so that telephone interference may be expected if the neutral is connected to ground. The useful capacity of the open delta – open Y bank is 87 percent of the capacity of the installed transformers when the two units are identical.




DELTA-Y FOR LIGHTING AND POWER

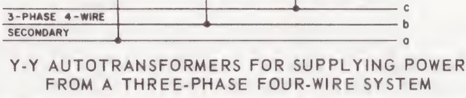
In the previous banks the single-phase lighting load is all on one phase resulting in unbalanced primary currents in any one bank. To eliminate this difficulty, the delta-Y system finds many uses. Here the neutral of the secondary three-phase system is grounded and the single-phase loads are connected between the different phase wires and the neutral while the three-phase loads are connected to the phase wires. Thus, the single-phase load can be balanced on three phases in each bank and banks may be paralleled if desired.

# TRANSFORMER CONNECTIONS




Y-Y FOR LIGHTING AND POWER

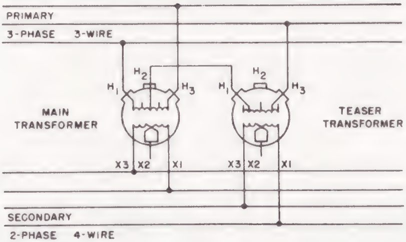
This diagram shows a system on which the primary voltage was increased from 2400 volts to 4160 volts to increase the potential capacity of the system. The previously delta connected distribution transformers are now connected from line to neutral. The secondaries are connected in Y. In this system the primary neutral is connected to the neutral of the supply voltage through a metallic conductor and carried with the phase conductor to minimize telephone interference. If the neutral of the transformer is isolated from the system neutral an unstable condition results at the transformer neutral caused primarily by third harmonic voltages. If the transformer neutral is connected to ground, the possibility of telephone interference is greatly enhanced and there is also a possibility of resonance between the line capacitance to ground and the magnetizing impedance of the transformer.




Y-Y AUTOTRANSFORMERS FOR SUPPLYING POWER FROM A THREE-PHASE FOUR-WIRE SYSTEM

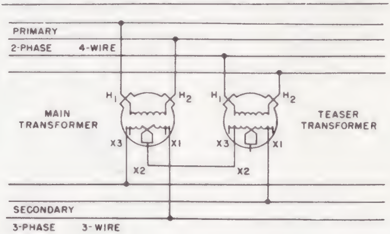
When the ratio of transformation from the primary to secondary voltage is small, the most economical way of stepping down the voltage is by using autotransformers as shown. For this application, it is necessary that the neutral of the autotransformer bank be connected to the system neutral.

# TRANSFORMER CONNECTIONS




SCOTT CONNECTION – THREE PHASE TO TWO PHASE

In some localities, two-phase power is required from a three-phase system. The Scott connection is the most popular method of making this phase change. The secondary may be either three, four, or five wire. Special taps must be provided at 50 percent and 86.6 percent of normal primary voltage in order to make this connection.

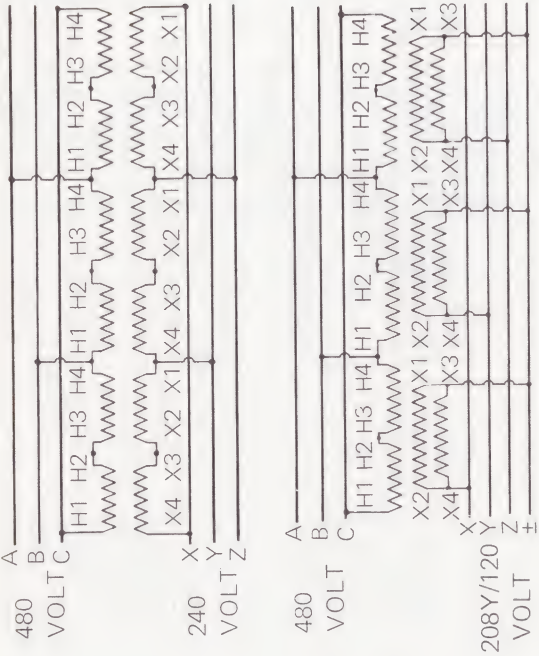



SCOTT CONNECTED TWO PHASE TO THREE PHASE

If it should be necessary to supply three-phase power from a two-phase system, the Scott connection may again be used In this case, of course, the special taps must be provided on the secondary side. In other respects, the connection is similar to the three-phase to two-phase transformation.

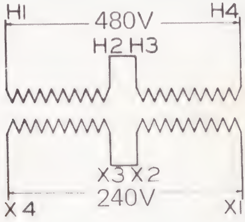
If it is desired to obtain the Scott transformation without a special 86.6 percent tapped transformer, it is possible to use one with a 10 percent or two 5 percent taps to approximate the desired value. It will introduce a small error of unbalance (overvoltage) which will require care in application.

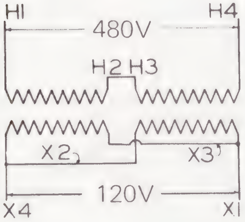
# TRANSFORMER CONNECTIONS

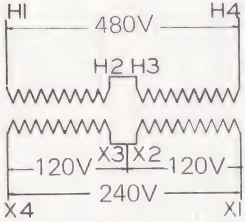


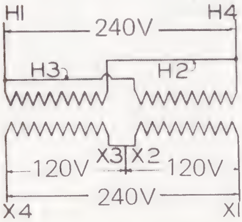
# TRANSFORMER CONNECTIONS

# TRANSFORMER CONNECTIONS

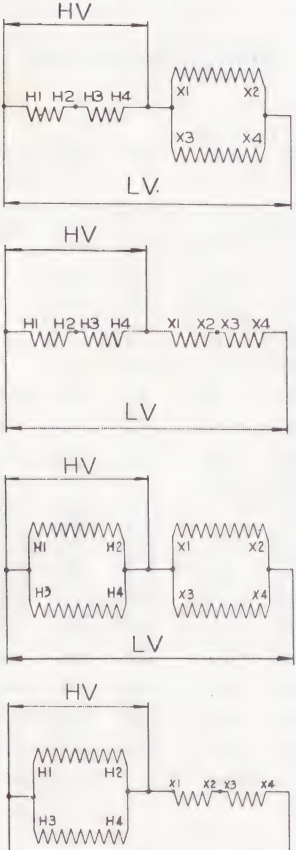


# BOOST AND BUCK CONNECTIONS




Diagrams for boost. For buck interchange $x_1$ and $x_4$, $x_2$ and $x_3$

# FULL LOAD CURRENTS THREE PHASE TRANSFORMERS

## Voltage (Line to Line)

| KVA Rating | 208 | 240 | 480 | 600 | 2400 | 4160 |
|---|---|---|---|---|---|---|
| 3 | 8.3 | 7.2 | 3.6 | 2.9 | .72 | .415 |
| 6 | 16.6 | 14.4 | 7.2 | 5.8 | 1.44 | .83 |
| 9 | 25 | 21.6 | 10.8 | 8.7 | 2.16 | 1.25 |
| 15 | 41.6 | 36.0 | 18.0 | 14.4 | 3.6 | 2.1 |
| 30 | 83 | 72 | 36 | 29 | 7.2 | 4.15 |
| 45 | 125 | 108 | 54 | 43 | 10.8 | 6.25 |
| 75 | 208 | 180 | 90 | 72 | 18 | 10.4 |
| 100 | 278 | 241 | 120 | 96 | 24 | 13.9 |
| 150 | 416 | 360 | 180 | 144 | 36 | 20.8 |
| 225 | 625 | 542 | 271 | 217 | 54 | 31.2 |
| 300 | 830 | 720 | 360 | 290 | 72 | 41.5 |
| 500 | 1390 | 1200 | 600 | 480 | 120 | 69.4 |
| 750 | 2080 | 1800 | 900 | 720 | 180 | 104 |
| 1000 | 2775 | 2400 | 1200 | 960 | 240 | 139 |
| 1500 | 4150 | 3600 | 1800 | 1440 | 360 | 208 |
| 2000 | 5550 | 4800 | 2400 | 1930 | 480 | 277 |
| 2500 | 6950 | 6000 | 3000 | 2400 | 600 | 346 |
| 5000 | 13900 | 12000 | 6000 | 4800 | 1200 | 694 |
| 7500 | 20800 | 18000 | 9000 | 7200 | 1800 | 1040 |
| 10000 | 27750 | 24000 | 12000 | 9600 | 2400 | 1386 |

For other KVA Ratings or Voltages:

$$\text{Amperes} = \frac{\text{KVA} \times 1000}{\text{Volts} \times 1.732}$$

# FULL LOAD CURRENTS
# SINGLE PHASE TRANSFORMERS

## Voltage

| KVA Rating | 120 | 208 | 240 | 480 | 600 | 2400 |
|---|---|---|---|---|---|---|
| 1 | 8.34 | 4.8 | 4.16 | 2.08 | 1.67 | .42 |
| 3 | 25 | 14.4 | 12.5 | 6.25 | 5.0 | 1.25 |
| 5 | 41.7 | 24.0 | 20.8 | 10.4 | 8.35 | 2.08 |
| 7.5 | 62.5 | 36.1 | 31.2 | 15.6 | 12.5 | 3.12 |
| 10 | 83.4 | 48 | 41.6 | 20.8 | 16.7 | 4.16 |
| 15 | 125 | 72 | 62.5 | 31.2 | 25.0 | 6.25 |
| 25 | 208 | 120 | 104 | 52 | 41.7 | 10.4 |
| 37.5 | 312 | 180 | 156 | 78 | 62.5 | 15.6 |
| 50 | 417 | 240 | 208 | 104 | 83.5 | 20.8 |
| 75 | 625 | 361 | 312 | 156 | 125 | 31.2 |
| 100 | 834 | 480 | 416 | 208 | 167 | 41.6 |
| 125 | 1042 | 600 | 520 | 260 | 208 | 52.0 |
| 167.5 | 1396 | 805 | 698 | 349 | 279 | 70.0 |
| 200 | 1666 | 960 | 833 | 416 | 333 | 83.3 |
| 250 | 2080 | 1200 | 1040 | 520 | 417 | 104 |
| 333 | 2776 | 1600 | 1388 | 694 | 555 | 139 |
| 500 | 4170 | 2400 | 2080 | 1040 | 835 | 208 |

For other KVA Ratings or Voltages:

$$\text{Amperes} = \frac{\text{KVA} \times 1000}{\text{Volts}}$$

# ALLOWABLE AMPACITIES OF

## Not More than Three Conductors in Raceway or Cable or Direct Burial (Based on Ambient Temperature of 30° C. 86° F.)

For Higher Temperatures, See Correction Factors Page 44.

| Size | Temperature Rating of Conductor. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AWG MCM | 60°C (140°F) | 75°C (167°F) | 85°C (185°F) | 90°C (194°F) | 110°C (230°F) | 125°C (257°F) | 200°C (392°F) | 250°C (482°F) |
| | TYPES RUW (14-2), T, TW, UF | TYPES RH, RHW, RUH (14-2), THW, THWN, XHHW, USE | TYPES V, MI | TYPES TA, TBS, SA, AVB, SIS, FEP, FEPB, RHH, THHN, XHHW** | TYPES AVA, AVL | TYPES AI (14-8), AIA | TYPES A (14-8), AA, FEP* FEPB* | TYPE TFE (Nickel or nickel-coated copper only) |
| 18 | .... | .... | .... | 21 | .... | .... | .... | .... |
| 16 | .... | .... | 22 | 22 | .... | .... | .... | .... |
| 14 | 15 | 15 | 25 | 25† | 30 | 30 | 30 | 40 |
| 12 | 20 | 20 | 30 | 30† | 35 | 40 | 40 | 55 |
| 10 | 30 | 30 | 40 | 40† | 45 | 50 | 55 | 75 |
| 8 | 40 | 45 | 50 | 50 | 60 | 65 | 70 | 95 |
| 6 | 55 | 65 | 70 | 70 | 80 | 85 | 95 | 120 |
| 4 | 70 | 85 | 90 | 90 | 105 | 115 | 120 | 145 |
| 3 | 80 | 100 | 105 | 105 | 120 | 130 | 145 | 170 |
| 2 | 95 | 115 | 120 | 120 | 135 | 145 | 165 | 195 |
| 1 | 110 | 130 | 140 | 140 | 160 | 170 | 190 | 220 |
| 1/0 | 125 | 150 | 155 | 155 | 190 | 200 | 225 | 250 |
| 2/0 | 145 | 175 | 185 | 185 | 215 | 230 | 250 | 280 |
| 3/0 | 165 | 200 | 210 | 210 | 245 | 265 | 285 | 315 |
| 4/0 | 195 | 230 | 235 | 235 | 275 | 310 | 340 | 370 |
| 250 | 215 | 255 | 270 | 270 | 315 | 335 | .... | .... |
| 300 | 240 | 285 | 300 | 300 | 345 | 380 | .... | .... |
| 350 | 260 | 310 | 325 | 325 | 390 | 420 | .... | .... |
| 400 | 280 | 335 | 360 | 360 | 420 | 450 | .... | .... |
| 500 | 320 | 380 | 405 | 405 | 470 | 500 | .... | .... |
| 600 | 355 | 420 | 455 | 455 | 525 | 545 | .... | .... |
| 700 | 385 | 460 | 490 | 490 | 560 | 600 | .... | .... |
| 750 | 400 | 475 | 500 | 500 | 580 | 620 | .... | .... |
| 800 | 410 | 490 | 515 | 515 | 600 | 640 | .... | .... |
| 900 | 435 | 520 | 555 | 555 | .... | .... | .... | .... |
| 1000 | 455 | 545 | 585 | 585 | 680 | 730 | .... | .... |
| 1250 | 495 | 590 | 645 | 645 | .... | .... | .... | .... |
| 1500 | 520 | 625 | 700 | 700 | 785 | .... | .... | .... |
| 1750 | 545 | 650 | 735 | 735 | .... | .... | .... | .... |
| 2000 | 560 | 665 | 775 | 775 | 840 | .... | .... | .... |

* Special use only.

** For dry locations only.

† The ampacities for Types FEP, FEPB, RHH, THHN, and XHHW conductors for sizes 14, 12, and 10 shall be the same as designated for 75°C conductors in this Table.

# INSULATED COPPER CONDUCTORS

## Single Conductor in Free Air (Based on Ambient Temperature of 30° C. 86° F.)

## For Higher Temperatures, See Correction Factors Page 44.

| Size | Temperature Rating of Conductor. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| AWG MCM | 60°C (140°F) | 75°C (167°F) | 85°C (185°F) | 90°C (194°F) | 110°C (230°F) | 125°C (257°F) | 200°C (392°F) | 250°C (482°F) | |
| | TYPES RUW (14-2), T, TW | TYPES RH, RHW, RUH (14-2), THW, THWN, XHHW | TYPES V, MI | TYPES TA, TBS, SA, AVB, SIS, FEP, FEPB, RHH, THHN, XHHW** | TYPES AVA, AVL | TYPES AI (14-8), AIA | TYPES A (14-8), AA, FEP* FEPB* | TYPE TFE (Nickel or nickel-coated copper only) | Bare and Covered Conductors |
| 18 | .... | .... | .... | 25 | .... | .... | .... | .... | .... |
| 16 | .... | .... | 27 | 27 | .... | .... | .... | .... | .... |
| 14 | 20 | 20 | 30 | 30† | 40 | 40 | 45 | 60 | 30 |
| 12 | 25 | 25 | 40 | 40† | 50 | 50 | 55 | 80 | 40 |
| 10 | 40 | 40 | 55 | 55† | 65 | 70 | 75 | 110 | 55 |
| 8 | 55 | 65 | 70 | 70 | 85 | 90 | 100 | 145 | 70 |
| 6 | 80 | 95 | 100 | 100 | 120 | 125 | 135 | 210 | 100 |
| 4 | 105 | 125 | 135 | 135 | 160 | 170 | 180 | 285 | 130 |
| 3 | 120 | 145 | 155 | 155 | 180 | 195 | 210 | 335 | 150 |
| 2 | 140 | 170 | 180 | 180 | 210 | 225 | 240 | 390 | 175 |
| 1 | 165 | 195 | 210 | 210 | 245 | 265 | 280 | 450 | 205 |
| 1/0 | 195 | 230 | 245 | 245 | 285 | 305 | 325 | 545 | 235 |
| 2/0 | 225 | 265 | 285 | 285 | 330 | 355 | 370 | 605 | 275 |
| 3/0 | 260 | 310 | 330 | 330 | 385 | 410 | 430 | 725 | 320 |
| 4/0 | 300 | 360 | 385 | 385 | 445 | 475 | 510 | 850 | 370 |
| 250 | 340 | 405 | 425 | 425 | 495 | 530 | .... | .... | 410 |
| 300 | 375 | 445 | 480 | 480 | 555 | 590 | .... | .... | 460 |
| 350 | 420 | 505 | 530 | 530 | 610 | 655 | .... | .... | 510 |
| 400 | 455 | 545 | 575 | 575 | 665 | 710 | .... | .... | 555 |
| 500 | 515 | 620 | 660 | 660 | 765 | 815 | .... | .... | 630 |
| 600 | 575 | 690 | 740 | 740 | 855 | 910 | .... | .... | 710 |
| 700 | 630 | 755 | 815 | 815 | 940 | 1005 | .... | .... | 780 |
| 750 | 655 | 785 | 845 | 845 | 980 | 1045 | .... | .... | 810 |
| 800 | 680 | 815 | 880 | 880 | 1020 | 1085 | .... | .... | 845 |
| 900 | 730 | 870 | 940 | 940 | .... | .... | .... | .... | 905 |
| 1000 | 780 | 935 | 1000 | 1000 | 1165 | 1240 | .... | .... | 965 |
| 1250 | 890 | 1065 | 1130 | 1130 | .... | .... | .... | .... | .... |
| 1500 | 980 | 1175 | 1260 | 1260 | 1450 | .... | .... | .... | 1215 |
| 1750 | 1070 | 1280 | 1370 | 1370 | .... | .... | .... | .... | .... |
| 2000 | 1155 | 1385 | 1470 | 1470 | 1715 | .... | .... | .... | 1405 |

* Special use only.

** For dry locations only.

† The ampacities for Types FEP, FEPB, RHH, THHN, and XHHW conductors for sizes 14, 12, and 10 shall be the same as designated for 75°C conductors in this Table.

# ALLOWABLE AMPACITIES OF

**Not More than Three Conductors in Raceway or Cable or Direct Burial (Based on Ambient Temperature of 30°C. 86°F.)**

**For Higher Temperatures,**

**See Correction Factors Page 44.**

| Size | Temperature Rating of Conductor. | | | | | | |
|---|---|---|---|---|---|---|---|
| AWG MCM | 60°C (140°F) | 75°C (167°F) | 85°C (185°F) | 90°C (194°F) | 110°C (230°F) | 125°C (257°F) | 200°C (392°F) |
| | TYPES RUW (12-2), T, TW, UF | TYPES RH, RHW, RUH (12-2), THW THWN XHHW, USE | TYPES V, MI | TYPES TA, TBS, SA, AVB, SIS, RHH THHN XHHW* | TYPES AVA, AVL | TYPES AI (12-8), AIA | TYPES A (12-8), AA |
| 12 | 15 | 15 | 25 | 25 † | 25 | 30 | 30 |
| 10 | 25 | 25 | 30 | 30 † | 35 | 40 | 45 |
| 8 | 30 | 40 | 40 | 40 | 45 | 50 | 55 |
| 6 | 40 | 50 | 55 | 55 | 60 | 65 | 75 |
| 4 | 55 | 65 | 70 | 70 | 80 | 90 | 95 |
| 3 | 65 | 75 | 80 | 80 | 95 | 100 | 115 |
| 2 | 75 | 90 | 95 | 95 | 105 | 115 | 130 |
| 1 | 85 | 100 | 110 | 110 | 125 | 135 | 150 |
| 1/0 | 100 | 120 | 125 | 125 | 150 | 160 | 180 |
| 2/0 | 115 | 135 | 145 | 145 | 170 | 180 | 200 |
| 3/0 | 130 | 155 | 165 | 165 | 195 | 210 | 225 |
| 4/0 | 155 | 180 | 185 | 185 | 215 | 245 | 270 |
| 250 | 170 | 205 | 215 | 215 | 250 | 270 | .... |
| 300 | 190 | 230 | 240 | 240 | 275 | 305 | .... |
| 350 | 210 | 250 | 260 | 260 | 310 | 335 | .... |
| 400 | 225 | 270 | 290 | 290 | 335 | 360 | .... |
| 500 | 260 | 310 | 330 | 330 | 380 | 405 | .... |
| 600 | 285 | 340 | 370 | 370 | 425 | 440 | .... |
| 700 | 310 | 375 | 395 | 395 | 455 | 485 | .... |
| 750 | 320 | 385 | 405 | 405 | 470 | 500 | .... |
| 800 | 330 | 395 | 415 | 415 | 485 | 520 | .... |
| 900 | 355 | 425 | 455 | 455 | .... | .... | .... |
| 1000 | 375 | 445 | 480 | 480 | 560 | 600 | .... |
| 1250 | 405 | 485 | 530 | 530 | .... | .... | .... |
| 1500 | 435 | 520 | 580 | 580 | 650 | .... | .... |
| 1750 | 455 | 545 | 615 | 615 | .... | .... | .... |
| 2000 | 470 | 560 | 650 | 650 | 705 | .... | .... |

* For dry locations only.

† The ampacities for Types RHH, THHN, and XHHW conductors for sizes 12 and 10 shall be the same as designated for 75°C conductors in this Table.

# INSULATED ALUMINUM CONDUCTORS

## Single Conductor in Free Air (Based on Ambient Temperature of 30°C. 86°F.)

### For Higher Temperatures, See Correction Factors Page 44.

| Size | Temperature Rating of Conductor. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AWG MCM | 60°C (140°F) | 75°C (167°F) | 85°C (185°F) | 90°C (194°F) | 110°C (230°F) | 125°C (257°F) | 200°C (392°F) | |
| | TYPES RUW (12-2), T, TW | TYPES RH, RHW, RUH (12-2), THW THWN XHHW | TYPES V, MI | TYPES TA, TBS, SA, AVB, SIS, RHH, THHN, XHHW* | TYPES AVA, AVL | TYPES AI (12-8), AIA | TYPES A (12-8), AA | Bare and Covered Conductors |
| 12 | 20 | 20 | 30 | 30 † | 40 | 40 | 45 | 30 |
| 10 | 30 | 30 | 45 | 45 † | 50 | 55 | 60 | 45 |
| 8 | 45 | 55 | 55 | 55 | 65 | 70 | 80 | 55 |
| 6 | 60 | 75 | 80 | 80 | 95 | 100 | 105 | 80 |
| 4 | 80 | 100 | 105 | 105 | 125 | 135 | 140 | 100 |
| 3 | 95 | 115 | 120 | 120 | 140 | 150 | 165 | 115 |
| 2 | 110 | 135 | 140 | 140 | 165 | 175 | 185 | 135 |
| 1 | 130 | 155 | 165 | 165 | 190 | 205 | 220 | 160 |
| 1/0 | 150 | 180 | 190 | 190 | 220 | 240 | 255 | 185 |
| 2/0 | 175 | 210 | 220 | 220 | 255 | 275 | 290 | 215 |
| 3/0 | 200 | 240 | 255 | 255 | 300 | 320 | 335 | 250 |
| 4/0 | 230 | 280 | 300 | 300 | 345 | 370 | 400 | 290 |
| 250 | 265 | 315 | 330 | 330 | 385 | 415 | .... | 320 |
| 300 | 290 | 350 | 375 | 375 | 435 | 460 | .... | 360 |
| 350 | 330 | 395 | 415 | 415 | 475 | 510 | .... | 400 |
| 400 | 355 | 425 | 450 | 450 | 520 | 555 | .... | 435 |
| 500 | 405 | 485 | 515 | 515 | 595 | 635 | .... | 490 |
| 600 | 455 | 545 | 585 | 585 | 675 | 720 | .... | 560 |
| 700 | 500 | 595 | 645 | 645 | 745 | 795 | .... | 615 |
| 750 | 515 | 620 | 670 | 670 | 775 | 825 | .... | 640 |
| 800 | 535 | 645 | 695 | 695 | 805 | 855 | .... | 670 |
| 900 | 580 | 700 | 750 | 750 | .... | .... | .... | 725 |
| 1000 | 625 | 750 | 800 | 800 | 930 | 990 | .... | 770 |
| 1250 | 710 | 855 | 905 | 905 | .... | .... | .... | .... |
| 1500 | 795 | 950 | 1020 | 1020 | 1175 | .... | .... | 985 |
| 1750 | 875 | 1050 | 1125 | 1125 | .... | .... | .... | .... |
| 2000 | 960 | 1150 | 1220 | 1220 | 1425 | .... | .... | 1165 |

* For dry locations only.

† The ampacities for Types RHH, THHN, and XHHW conductors for sizes 12 and 10 shall be the same as designated for 75°C conductors in this Table.

# CORRECTION FACTORS FOR ROOM TEMPERATURES OVER 30° C (86° F)

## (For Ampacities on Insulated Copper and Aluminum Conductors, See Pages 40 thru 43)

## CONDUCTOR TEMPERATURE RATING

| C. | F. | 60°C (140°F) | 75°C (167°F) | 85°C (185°F) | 90°C (194°F) | 110°C (230°F) | 125°C (257°F) | 200°C (392°F) | 250°C (482°F) |
|---|---|---|---|---|---|---|---|---|---|
| 40 | 104 | .82 | .88 | .90 | .91 | .94 | .95 | .... | .... |
| 45 | 113 | .71 | .82 | .85 | .87 | .90 | .92 | .... | .... |
| 50 | 122 | .58 | .75 | .80 | .82 | .87 | .89 | .... | .... |
| 55 | 131 | .41 | .67 | .74 | .76 | .83 | .86 | .... | .... |
| 60 | 140 | .... | .58 | .67 | .71 | .79 | .83 | .91 | .95 |
| 70 | 158 | .... | .35 | .52 | .58 | .71 | .76 | .87 | .91 |
| 75 | 167 | .... | .... | .43 | .50 | .66 | .72 | .86 | .89 |
| 80 | 176 | .... | .... | .30 | .41 | .61 | .69 | .84 | .87 |
| 90 | 194 | .... | .... | .... | .... | .50 | .61 | .80 | .83 |
| 100 | 212 | .... | .... | .... | .... | .... | .51 | .77 | .80 |
| 120 | 248 | .... | .... | .... | .... | .... | .... | .69 | .72 |
| 140 | 284 | .... | .... | .... | .... | .... | .... | .59 | .59 |
| 160 | 320 | .... | .... | .... | .... | .... | .... | .... | .54 |
| 180 | 356 | .... | .... | .... | .... | .... | .... | .... | .50 |
| 200 | 392 | .... | .... | .... | .... | .... | .... | .... | .43 |
| 225 | 437 | .... | .... | .... | .... | .... | .... | .... | .30 |

## DERATING FACTORS FOR MORE CONDUCTORS

| Conductors | % Value | Conductors | % Value |
|---|---|---|---|
| 4-6 | 80 | 25-42 | 60 |
| 7-24 | 70 | 43 & over | 50 |

# Maximum Number of Conductors in Trade Sizes of Conduit or Tubing

| Type Letters | Conductor Size AWG, MCM | ½ | ¾ | 1 | 1¼ | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TW, T, RUH, | 14 | 9 | 15 | 25 | 44 | 60 | 99 | 142 | | | | | | |
| RUW, | 12 | 7 | 12 | 19 | 35 | 47 | 78 | 111 | 171 | | | | | |
| XHHW (14 thru 8) | 10 | 5 | 9 | 15 | 26 | 36 | 60 | 85 | 131 | 176 | | | | |
| | 8 | 2 | 4 | 7 | 12 | 17 | 28 | 40 | 62 | 84 | 108 | | | |
| RHW and RHH | 14 | 6 | 10 | 16 | 29 | 40 | 65 | 93 | 143 | 192 | | | | |
| (without outer | 12 | 4 | 8 | 13 | 24 | 32 | 53 | 76 | 117 | 157 | | | | |
| covering), | 10 | 4 | 6 | 11 | 19 | 26 | 43 | 61 | 95 | 127 | 163 | | | |
| THW | 8 | 1 | 3 | 5 | 10 | 13 | 22 | 32 | 49 | 66 | 85 | 106 | 133 | |
| TW, | 6 | 1 | 2 | 4 | 7 | 10 | 16 | 23 | 36 | 48 | 62 | 78 | 97 | 141 |
| T, | 4 | 1 | 1 | 3 | 5 | 7 | 12 | 17 | 27 | 36 | 47 | 58 | 73 | 106 |
| THW, | 3 | 1 | 1 | 2 | 4 | 6 | 10 | 15 | 23 | 31 | 40 | 50 | 63 | 91 |
| RUH (6 thru 2), | 2 | 1 | 1 | 2 | 4 | 5 | 9 | 13 | 20 | 27 | 34 | 43 | 54 | 78 |
| RUW (6 thru 2), | 1 | | 1 | 1 | 3 | 4 | 6 | 9 | 14 | 19 | 25 | 31 | 39 | 57 |
| FEPB (6 thru 2), | 0 | | 1 | 1 | 2 | 3 | 5 | 8 | 12 | 16 | 21 | 27 | 33 | 49 |
| RHW and | 00 | | 1 | 1 | 1 | 3 | 5 | 7 | 10 | 14 | 18 | 23 | 29 | 41 |
| RHH (with- | 000 | | 1 | 1 | 1 | 2 | 4 | 6 | 9 | 12 | 15 | 19 | 24 | 35 |
| out outer | 0000 | | | 1 | 1 | 1 | 3 | 5 | 7 | 10 | 13 | 16 | 20 | 29 |
| covering) | 250 | | | 1 | 1 | 1 | 2 | 4 | 6 | 8 | 10 | 13 | 16 | 23 |
| | 300 | | | 1 | 1 | 1 | 2 | 3 | 5 | 7 | 9 | 11 | 14 | 20 |
| | 350 | | | | 1 | 1 | 1 | 3 | 4 | 6 | 8 | 10 | 12 | 18 |
| | 400 | | | | 1 | 1 | 1 | 2 | 4 | 5 | 7 | 9 | 11 | 16 |
| | 500 | | | | 1 | 1 | 1 | 1 | 3 | 4 | 6 | 7 | 9 | 14 |
| | 600 | | | | | 1 | 1 | 1 | 3 | 4 | 5 | 6 | 7 | 11 |
| | 700 | | | | | 1 | 1 | 1 | 2 | 3 | 4 | 5 | 7 | 10 |
| | 750 | | | | | 1 | 1 | 1 | 2 | 3 | 4 | 5 | 6 | 9 |

Conduit Trade Size (Inches): ½ through 6

# Maximum Number of Conductors in Trade Sizes of Conduit or Tubing

| Conduit Trade Size (Inches) | | ½ | ¾ | 1 | 1¼ | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type Letters | Conductor Size AWG, MCM | | | | | | | | | | | | | |
| | 14 | 13 | 24 | 39 | 69 | 94 | 154 | | | | | | | |
| | 12 | 10 | 18 | 29 | 51 | 70 | 114 | 164 | | | | | | |
| THWN, | 10 | 6 | 11 | 18 | 32 | 44 | 73 | 104 | 160 | | | | | |
| | 8 | 3 | 5 | 9 | 16 | 22 | 36 | 51 | 79 | 106 | 136 | | | |
| THHN, | 6 | 1 | 4 | 6 | 11 | 15 | 26 | 37 | 57 | 76 | 98 | 125 | 154 | |
| | 4 | 1 | 2 | 4 | 7 | 9 | 16 | 22 | 35 | 47 | 60 | 75 | 94 | 137 |
| FEP (14 thru 2), | 3 | 1 | 1 | 3 | 6 | 8 | 13 | 19 | 29 | 39 | 51 | 64 | 80 | 116 |
| FEPB (14 thru 8), | 2 | 1 | 1 | 3 | 5 | 7 | 11 | 16 | 25 | 33 | 43 | 54 | 67 | 97 |
| | 1 | | 1 | 1 | 3 | 5 | 8 | 12 | 18 | 25 | 32 | 40 | 50 | 72 |
| XHHW (4 thru | 0 | | 1 | 1 | 3 | 4 | 7 | 10 | 15 | 21 | 27 | 33 | 42 | 61 |
| 500MCM) | 00 | | 1 | 1 | 2 | 3 | 6 | 8 | 13 | 17 | 22 | 28 | 35 | 51 |
| | 000 | | 1 | 1 | 1 | 3 | 5 | 7 | 11 | 14 | 18 | 23 | 29 | 42 |
| | 0000 | | 1 | 1 | 1 | 2 | 4 | 6 | 9 | 12 | 15 | 19 | 24 | 35 |
| | 250 | | | 1 | 1 | 1 | 3 | 4 | 7 | 10 | 12 | 16 | 20 | 28 |
| | 300 | | | 1 | 1 | 1 | 3 | 4 | 6 | 8 | 11 | 13 | 17 | 24 |
| | 350 | | | 1 | 1 | 1 | 2 | 3 | 5 | 7 | 9 | 12 | 15 | 21 |
| | 400 | | | | 1 | 1 | 1 | 3 | 5 | 6 | 8 | 10 | 13 | 19 |
| | 500 | | | | 1 | 1 | 1 | 2 | 4 | 5 | 7 | 9 | 11 | 16 |
| | 600 | | | | 1 | 1 | 1 | 1 | 3 | 4 | 5 | 7 | 9 | 13 |
| | 700 | | | | | 1 | 1 | 1 | 3 | 4 | 5 | 6 | 8 | 11 |
| | 750 | | | | | 1 | 1 | 1 | 2 | 3 | 4 | 6 | 7 | 11 |
| XHHW | 6 | 1 | 3 | 5 | 9 | 13 | 21 | 30 | 47 | 63 | 81 | 102 | 128 | 185 |
| | 600 | | | | 1 | 1 | 1 | 1 | 3 | 4 | 5 | 7 | 9 | 13 |
| | 700 | | | | | 1 | 1 | 1 | 3 | 4 | 5 | 6 | 7 | 11 |
| | 750 | | | | | 1 | 1 | 1 | 2 | 3 | 4 | 6 | 7 | 10 |

# Maximum Number of Conductors in Trade Sizes of Conduit or Tubing

| Conduit Trade Size (Inches) | | ½ | ¾ | 1 | 1¼ | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type Letters | Conductor Size AWG, MCM | | | | | | | | | | | | | |
| | 14 | 3 | 6 | 10 | 18 | 25 | 41 | 58 | 90 | 121 | 155 | | | |
| | 12 | 3 | 5 | 9 | 15 | 21 | 35 | 50 | 77 | 103 | 132 | | | |
| RHW, | 10 | 2 | 4 | 7 | 13 | 18 | 29 | 41 | 64 | 86 | 110 | 138 | | |
| | 8 | 1 | 2 | 4 | 7 | 9 | 16 | 22 | 35 | 47 | 60 | 75 | 94 | 137 |
| RHH | 6 | 1 | 1 | 2 | 5 | 6 | 11 | 15 | 24 | 32 | 41 | 51 | 64 | 93 |
| | 4 | 1 | 1 | 1 | 3 | 5 | 8 | 12 | 18 | 24 | 31 | 39 | 50 | 72 |
| (with | 3 | 1 | 1 | 1 | 3 | 4 | 7 | 10 | 16 | 22 | 28 | 35 | 44 | 63 |
| outer | 2 | | 1 | 1 | 3 | 4 | 6 | 9 | 14 | 19 | 24 | 31 | 38 | 56 |
| covering) | 1 | | 1 | 1 | 1 | 3 | 5 | 7 | 11 | 14 | 18 | 23 | 29 | 42 |
| | 0 | | 1 | 1 | 1 | 2 | 4 | 6 | 9 | 12 | 16 | 20 | 25 | 37 |
| | 00 | | | 1 | 1 | 1 | 3 | 5 | 8 | 11 | 14 | 18 | 22 | 32 |
| | 000 | | | 1 | 1 | 1 | 3 | 4 | 7 | 9 | 12 | 15 | 19 | 28 |
| | 0000 | | | 1 | 1 | 1 | 2 | 4 | 6 | 8 | 10 | 13 | 16 | 24 |
| | 250 | | | | 1 | 1 | 1 | 3 | 5 | 6 | 8 | 11 | 13 | 19 |
| | 300 | | | | 1 | 1 | 1 | 3 | 4 | 5 | 7 | 9 | 11 | 17 |
| | 350 | | | | 1 | 1 | 1 | 2 | 4 | 5 | 6 | 8 | 10 | 15 |
| | 400 | | | | 1 | 1 | 1 | 1 | 3 | 4 | 6 | 7 | 9 | 14 |
| | 500 | | | | 1 | 1 | 1 | 1 | 3 | 4 | 5 | 6 | 8 | 11 |
| | 600 | | | | | 1 | 1 | 1 | 2 | 3 | 4 | 5 | 6 | 9 |
| | 700 | | | | | 1 | 1 | 1 | 1 | 3 | 3 | 4 | 6 | 8 |
| | 750 | | | | | | 1 | 1 | 1 | 3 | 3 | 4 | 5 | 8 |

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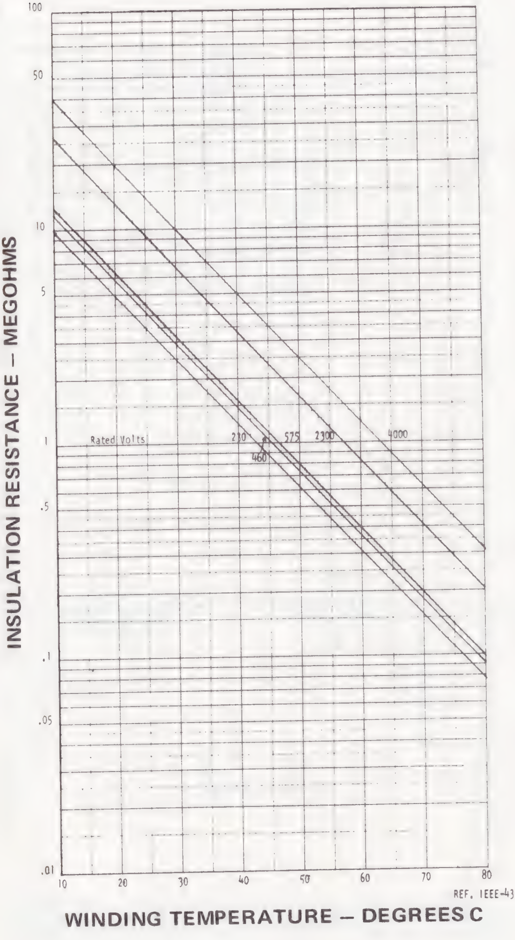
# MINIMUM INSULATION RESISTANCE



## EFFECTS OF UNBALANCED VOLTAGE ON MOTOR PERFORMANCE

Alternating-current polyphase motors shall operate successfully under running conditions at rated load when the voltage unbalance at the motor terminals does not exceed 1 percent. Performance will not necessarily be the same as when the motor is operating with a balanced voltage at the motor terminals.

A relatively small unbalance in voltage will cause a considerable increase in temperature rise. In the phase with the highest current, the percentage increase in temperature rise will be approximately two times the square of the percentage voltage unbalance. The increase in losses and, consequently, the increase in average heating of the whole winding will be slightly lower than the winding with the highest current.

To illustrate the severity of this condition, an approximate 3.5 per cent voltage unbalance will cause an approximate 25 per cent increase in temperature rise.

Reference NEMA Standards MGI- 12.45A and 14.34C-January 1974.

# POWER-FACTOR IMPROVEMENT

## Capacitor Multipliers for Kilowatt Load

(To give capacitor kvar required to improve power factor from original to desired value — see sample below.)

| Original Power Factor, Per Cent | Desired Power Factor—Per Cent | | | | |
|---|---|---|---|---|---|
| | 100 | 95 | 90 | 85 | 80 |
| 60 | 1.333 | 1.004 | 0.849 | 0.713 | 0.583 |
| 62 | 1.266 | 0.937 | 0.782 | 0.646 | 0.516 |
| 64 | 1.201 | 0.872 | 0.717 | 0.581 | 0.451 |
| 66 | 1.138 | 0.809 | 0.654 | 0.518 | 0.388 |
| 68 | 1.078 | 0.749 | 0.594 | 0.458 | 0.328 |
| 70 | 1.020 | 0.691 | 0.536 | 0.400 | 0.270 |
| 72 | 0.964 | 0.635 | 0.480 | 0.344 | 0.214 |
| 74 | 0.909 | 0.580 | 0.425 | 0.289 | 0.159 |
| 76 | 0.855 | 0.526 | 0.371 | 0.235 | 0.105 |
| 77 | 0.829 | 0.500 | 0.345 | 0.209 | 0.079 |
| 78 | 0.802 | 0.473 | 0.318 | 0.182 | 0.052 |
| 79 | 0.776 | 0.447 | 0.292 | 0.156 | 0.026 |
| 80 | 0.750 | 0.421 | 0.266 | 0.130 | |
| 81 | 0.724 | 0.395 | 0.240 | 0.104 | |
| 82 | 0.698 | 0.369 | 0.214 | 0.078 | |
| 83 | 0.672 | 0.343 | 0.188 | 0.052 | |
| 84 | 0.646 | 0.317 | 0.162 | 0.206 | |
| 85 | 0.620 | 0.291 | 0.136 | | |
| 86 | 0.593 | 0.264 | 0.109 | | |
| 87 | 0.567 | 0.238 | 0.083 | | |
| 88 | 0.540 | 0.211 | 0.056 | | |
| 89 | 0.512 | 0.183 | 0.028 | | |
| 90 | 0.484 | 0.155 | | | |
| 91 | 0.456 | 0.127 | | | |
| 92 | 0.426 | 0.097 | | | |
| 93 | 0.395 | 0.066 | | | |
| 94 | 0.363 | 0.034 | | | |
| 95 | 0.329 | | | | |
| 96 | 0.292 | | | | |
| 97 | 0.251 | | | | |
| 99 | 0.143 | | | | |

Assume total plant load is 100 kw at 60 per cent power factor. Capacitor kvar rating necessary to improve power factor to 80 per cent is found by multiplying kw (100) by multiplier in table (0.583), which gives kvar (58.3). Nearest standard rating (60 kvar) should be recommended.

# CAPACITOR SWITCHING DEVICES

## Recommended Switching Devices (for separate mounting)

| Capacitor Rating: Volts | Capacitor Rating: Kvac | Amperes: Capacitor Rated Current | Amperes: Safety Switch Fuse Rating | Amperes: AB-I Breaker Trip Rating | Amperes: DB Breaker Trip Rating |
|---|---|---|---|---|---|
| 240 | 2½ | 6.01 | 15 | 15 | 15 |
| | 5 | 12.0 | 20 | 20 | 20 |
| | 7½ | 18.0 | 30 | 30 | 30 |
| | 10 | 24.1 | 40 | 40 | 40 |
| | 15 | 36.1 | 60 | 70 | 50 |
| | 30 | 72.2 | 125 | 125 | 100 |
| | 45 | 108 | 200 | 175 | 150 |
| | 60 | 144 | 250 | 225 | 200 |
| | 75 | 180 | 300 | 275 | 250 |
| | 90 | 217 | 400 | 350 | 300 |
| | 120 | 289 | 500 | 500 | 400 |
| | 135 | 325 | 600 | 500 | 500 |
| | 150 | 361 | 600 | 600 | 500 |
| | 180 | 433 | 800 | 700 | 600 |
| | 225 | 541 | 900 | 900 | 800 |
| | 240 | 578 | 1000 | 900 | 800 |
| | 270 | 650 | 1200 | 1000 | 1000 |
| | 360 | 866 | 1600 | .... | 1200 |
| 480 | 2 | 2.41 | 15 | 15 | 15 |
| | 5 | 6.01 | 15 | 15 | 15 |
| | 7½ | 9.0 | 15 | 15 | 15 |
| | 10 | 12.0 | 20 | 20 | 20 |
| | 15 | 18.0 | 30 | 30 | 30 |
| | 20 | 24.0 | 40 | 40 | 40 |
| | 25 | 30.0 | 60 | 50 | 50 |
| | 30 | 36.1 | 60 | 70 | 50 |
| | 40 | 48.1 | 80 | 100 | 70 |
| | 50 | 60.1 | 100 | 100 | 90 |
| | 60 | 72.2 | 125 | 125 | 100 |
| | 75 | 90.2 | 150 | 150 | 125 |
| | 80 | 96.2 | 175 | 150 | 150 |
| | 90 | 108 | 200 | 175 | 150 |
| | 100 | 120 | 200 | 200 | 175 |
| | 120 | 144 | 250 | 225 | 200 |
| | 125 | 150 | 250 | 225 | 200 |
| | 150 | 180 | 300 | 300 | 250 |
| | 160 | 192 | 350 | 300 | 300 |
| | 180 | 216 | 400 | 350 | 300 |
| | 200 | 241 | 400 | 400 | 350 |
| | 225 | 271 | 500 | 500 | 400 |
| | 240 | 289 | 500 | 500 | 400 |
| | 250 | 301 | 500 | 500 | 400 |
| | 300 | 361 | 600 | 600 | 500 |
| | 320 | 385 | 700 | 600 | 600 |
| | 360 | 433 | 800 | 700 | 600 |
| | 375 | 451 | 800 | 700 | 600 |
| | 400 | 481 | 800 | 800 | 800 |
| | 450 | 541 | 900 | 900 | 800 |
| 600 | 5 | 4.81 | 15 | 15 | 15 |
| | 10 | 9.62 | 20 | 15 | 15 |
| | 15 | 14.4 | 25 | 30 | 20 |
| | 20 | 19.2 | 35 | 30 | 30 |
| | 25 | 24.1 | 40 | 40 | 40 |
| | 30 | 28.9 | 50 | 50 | 40 |
| | 40 | 38.5 | 70 | 70 | 70 |
| | 50 | 48.1 | 80 | 100 | 70 |
| | 60 | 57.8 | 100 | 100 | 90 |
| | 75 | 72.2 | 125 | 125 | 100 |
| | 80 | 77.0 | 150 | 125 | 125 |
| | 100 | 96.2 | 175 | 150 | 150 |
| | 120 | 115 | 200 | 175 | 175 |
| | 125 | 120 | 200 | 200 | 175 |
| | 150 | 144 | 250 | 225 | 200 |
| | 160 | 154 | 300 | 250 | 225 |
| | 180 | 173 | 300 | 300 | 250 |
| | 200 | 192 | 350 | 300 | 300 |
| | 225 | 217 | 400 | 350 | 300 |
| | 240 | 231 | 400 | 350 | 350 |
| | 250 | 241 | 400 | 400 | 350 |
| | 300 | 289 | 500 | 500 | 400 |
| | 320 | 306 | 600 | 500 | 500 |
| | 360 | 347 | 600 | 600 | 500 |
| | 375 | 361 | 600 | 600 | 500 |
| | 400 | 385 | 700 | 600 | 600 |
| | 450 | 433 | 800 | 700 | 600 |

# MAXIMUM SUGGESTED CAPACITOR KVAR FOR USE WITH OPEN-TYPE, 3 PHASE, 60 HERTZ, 600 VOLTS OR LESS, U FRAME, NEMA DESIGN B MOTORS

| Induction Motor Horse-power Rating | Nominal Motor Speed in Rpm and Number of Poles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3600 2 | | 1800 4 | | 1200 6 | | 900 8 | | 720 10 | | 600 12 | |
| | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR |
| 25 | 4 | 7 | 5 | 9 | 5 | 11 | 7.5 | 12 | 10 | 23 | 10 | 23 |
| 30 | 5 | 7 | 7.5 | 9 | 5 | 11 | 10 | 12 | 10 | 15 | 10 | 19 |
| 40 | 5 | 5 | 7.5 | 9 | 10 | 11 | 10 | 12 | 10 | 15 | 15 | 19 |
| 50 | 7.5 | 5 | 10 | 7 | 10 | 9 | 15 | 12 | 20 | 15 | 25 | 19 |
| 60 | 7.5 | 5 | 10 | 7 | 10 | 9 | 15 | 11 | 20 | 15 | 30 | 19 |
| 75 | 10 | 5 | 10 | 7 | 15 | 9 | 15 | 10 | 30 | 15 | 40 | 19 |
| 100 | 15 | 5 | 20 | 7 | 25 | 9 | 30 | 10 | 40 | 15 | 45 | 17 |
| 125 | 15 | 5 | 20 | 7 | 30 | 9 | 35 | 10 | 45 | 15 | 50 | 17 |
| 150 | 15 | 5 | 25 | 6 | 30 | 9 | 40 | 9 | 50 | 13 | 60 | 17 |
| 200 | 40 | 5 | 40 | 6 | 45 | 8 | 50 | 9 | 70 | 13 | 75 | 17 |
| 250 | 45 | 5 | 50 | 6 | 50 | 8 | 70 | 9 | 75 | 12 | 90 | 17 |
| 300 | 50 | 5 | 50 | 6 | 70 | 8 | 75 | 9 | 75 | 11 | 105 | 17 |
| 350 | 50 | 5 | 50 | 5 | 75 | 8 | 80 | 9 | 80 | 11 | 105 | 17 |
| 400 | 60 | 5 | 60 | 5 | 75 | 8 | 100 | 9 | 100 | 11 | 110 | 17 |
| 450 | 60 | 5 | 75 | 5 | 75 | 6 | 100 | 9 | 100 | 11 | 110 | 17 |
| 500 | 70 | 5 | 90 | 5 | 90 | 6 | 110 | 9 | 120 | 11 | 120 | 17 |

"% AR — Percent Ampere Reduction"

## MAXIMUM SUGGESTED CAPACITOR KVAR FOR USE WITH OPEN-TYPE, 3 PHASE, 60 HERTZ, 600 VOLTS OR LESS, T FRAME, NEMA DESIGN B MOTORS

| Induction Motor Horse-power Rating | Nominal Motor Speed in Rpm and Number of Poles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3600<br>2 | | 1800<br>4 | | 1200<br>6 | | 900<br>8 | | 720<br>10 | | 600<br>12 | |
| | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR |
| 20 | 5 | 11 | 7.5 | 17 | 7.5 | 19 | 10 | 23 | 10 | 29 | 15 | 34 |
| 25 | 7.5 | 11 | 7.5 | 17 | 7.5 | 19 | 10 | 23 | 10 | 24 | 20 | 34 |
| 30 | 7.5 | 10 | 7.5 | 17 | 10 | 19 | 15 | 23 | 15 | 24 | 25 | 32 |
| 40 | 7.5 | 10 | 15 | 17 | 15 | 19 | 20 | 23 | 20 | 24 | 30 | 32 |
| 50 | 10 | 10 | 20 | 17 | 20 | 19 | 25 | 23 | 20 | 24 | 35 | 32 |
| 60 | 10 | 10 | 20 | 17 | 30 | 19 | 30 | 23 | 30 | 22 | 45 | 32 |
| 75 | 15 | 10 | 25 | 14 | 30 | 16 | 30 | 17 | 35 | 21 | 40 | 19 |
| 100 | 15 | 10 | 30 | 14 | 30 | 12 | 35 | 16 | 40 | 15 | 45 | 17 |
| 125 | 30 | 10 | 35 | 12 | 30 | 12 | 50 | 16 | 45 | 15 | 50 | 17 |
| 150 | 30 | 10 | 35 | 11 | 35 | 12 | 50 | 14 | 50 | 13 | 60 | 17 |
| 200 | 35 | 10 | 50 | 11 | 55 | 12 | 70 | 14 | 70 | 13 | 90 | 17 |
| 250 | 35 | 10 | 55 | 9 | 70 | 12 | 85 | 14 | 90 | 13 | 100 | 17 |
| 300 | 35 | 10 | 65 | 9 | 75 | 12 | 95 | 14 | 100 | 13 | 110 | 17 |
| 350 | 40 | 10 | 80 | 9 | 85 | 12 | 125 | 14 | 120 | 13 | 150 | 17 |
| 400 | 100 | 10 | 80 | 8 | 100 | 12 | 140 | 14 | 150 | 13 | 150 | 17 |
| 450 | 100 | 9 | 90 | 8 | 140 | 12 | 150 | 13 | 150 | 13 | 175 | 17 |
| 500 | 100 | 8 | 115 | 8 | 150 | 12 | 150 | 12 | 175 | 13 | 175 | 17 |

"% AR — Percent Ampere Reduction"

# MAXIMUM SUGGESTED CAPACITOR KVAR FOR USE WITH TEFC, 3 PHASE, 60 HERTZ, 600 VOLTS OR LESS, U FRAME, NEMA DESIGN B MOTORS

| Induction Motor Horse-power Rating | Nominal Motor Speed in Rpm and Number of Poles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3600<br>2 | | 1800<br>4 | | 1200<br>6 | | 900<br>8 | | 720<br>10 | | 600<br>12 | |
| | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR |
| 25 | 5 | 6 | 5 | 8 | 5 | 9 | 7.5 | 15 | 10 | 17 | 10 | 18 |
| 30 | 5 | 6 | 7.5 | 8 | 7.5 | 9 | 10 | 15 | 10 | 15 | 10 | 18 |
| 40 | 7.5 | 6 | 10 | 8 | 10 | 9 | 10 | 15 | 10 | 15 | 15 | 17 |
| 50 | 7.5 | 6 | 10 | 8 | 10 | 9 | 15 | 12 | 15 | 12 | 20 | 17 |
| 60 | 10 | 6 | 10 | 8 | 10 | 9 | 15 | 12 | 20 | 12 | 25 | 17 |
| 75 | 15 | 6 | 15 | 8 | 15 | 9 | 20 | 11 | 25 | 12 | 35 | 17 |
| 100 | 15 | 6 | 20 | 8 | 25 | 9 | 25 | 11 | 40 | 12 | 45 | 17 |
| 125 | 20 | 6 | 25 | 7 | 30 | 9 | 30 | 11 | 45 | 12 | 45 | 15 |
| 150 | 25 | 6 | 30 | 7 | 30 | 9 | 40 | 11 | 45 | 12 | 50 | 15 |
| 200 | 35 | 6 | 40 | 7 | 60 | 9 | 60 | 11 | 55 | 11 | 60 | 13 |
| 250 | 40 | 5 | 50 | 6 | 60 | 9 | 80 | 11 | 60 | 11 | 100 | 13 |
| 300 | 50 | 5 | 45 | 6 | 80 | 8 | 80 | 10 | 80 | 10 | 125 | 13 |
| 350 | 60 | 5 | 70 | 6 | 80 | 8 | 80 | 9 | ... | ... | ... | ... |
| 400 | 60 | 5 | 80 | 6 | 80 | 6 | 160 | ... | ... | ... | ... | ... |
| 450 | 70 | 5 | 100 | 6 | ... | ... | ... | ... | ... | ... | ... | ... |
| 500 | 70 | 5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |

"% AR — Percent Ampere Reduction"

# MAXIMUM SUGGESTED CAPACITOR KVAR FOR USE WITH TEFC, 3 PHASE, 60 HERTZ, 600 VOLTS OR LESS, T FRAME, NEMA DESIGN B MOTORS

| Induction Motor Horse-power Rating | Nominal Motor Speed in Rpm and Number of Poles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3600 | | 1800 | | 1200 | | 900 | | 720 | | 600 | |
| | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR | Kvar | % AR |
| 25 | 5 | 10 | 7.5 | 17 | 10 | 21 | 10 | 22 | 10 | 22 | 20 | 31 |
| 30 | 5 | 10 | 7.5 | 17 | 10 | 21 | 15 | 22 | 15 | 22 | 20 | 31 |
| 40 | 10 | 10 | 10 | 12 | 15 | 21 | 20 | 22 | 20 | 22 | 30 | 31 |
| 50 | 10 | 10 | 15 | 12 | 25 | 21 | 23 | 21 | 25 | 22 | 35 | 31 |
| 60 | 12 | 9 | 15 | 12 | 25 | 19 | 25 | 19 | 30 | 22 | 40 | 30 |
| 75 | 15 | 9 | 20 | 12 | 25 | 15 | 30 | 19 | 35 | 21 | 40 | 30 |
| 100 | 20 | 9 | 30 | 12 | 25 | 13 | 40 | 19 | 40 | 12 | 50 | 30 |
| 125 | 20 | 9 | 35 | 12 | 30 | 13 | 45 | 18 | 50 | 12 | 50 | 30 |
| 150 | 25 | 9 | 40 | 11 | 25 | 13 | 55 | 18 | 50 | 12 | 70 | 30 |
| 200 | 30 | 9 | 40 | 8 | 60 | 13 | 60 | 18 | 70 | 12 | 75 | 30 |
| 250 | 60 | 9 | 50 | 8 | 60 | 13 | 115 | 18 | 100 | 12 | 125 | 30 |
| 300 | 65 | 7 | 50 | 8 | 60 | 13 | 140 | 18 | 125 | 12 | 150 | 30 |
| 350 | 70 | 7 | 55 | 8 | 80 | 13 | 160 | 18 | 150 | 12 | 150 | 30 |
| 400 | 70 | 7 | 60 | 8 | 130 | 13 | 160 | 17 | 175 | 12 | 175 | 30 |
| 450 | 90 | 7 | 95 | 8 | 145 | 13 | 160 | 17 | 175 | 12 | 200 | 30 |
| 500 | 100 | 7 | 110 | 7 | 170 | 13 | 210 | 17 | ... | .. | ... | .. |

"% AR — Percent Ampere Reduction"

# TEMPERATURE CONVERSION TABLE

"Locate Known temperature in °C/°F column. Read converted temperature in °C or °F column."

| °C | °C/°F | °F | °C | °C/°F | °F | °C | °C/°F | °F |
|---|---|---|---|---|---|---|---|---|
| −45.4 | −50 | −58 | 15.5 | 60 | 140 | 76.5 | 170 | 338 |
| −42.7 | −45 | −49 | 18.3 | 65 | 149 | 79.3 | 175 | 347 |
| −40 | −40 | −40 | 21.1 | 70 | 158 | 82.1 | 180 | 356 |
| −37.2 | −35 | −31 | 23.9 | 75 | 167 | 85 | 185 | 365 |
| −34.4 | −30 | −22 | 26.6 | 80 | 176 | 87.6 | 190 | 374 |
| −32.2 | −25 | −13 | 29.4 | 85 | 185 | 90.4 | 195 | 383 |
| −29.4 | −20 | −4 | 32.2 | 90 | 194 | 93.2 | 200 | 392 |
| −26.6 | −15 | 5 | 35 | 95 | 203 | 96 | 205 | 401 |
| −23.8 | −10 | 14 | 37.8 | 100 | 212 | 98.8 | 210 | 410 |
| −20.5 | −5 | 23 | 40.5 | 105 | 221 | 101.6 | 215 | 419 |
| −17.8 | 0 | 32 | 43.4 | 110 | 230 | 104.4 | 220 | 428 |
| −15 | 5 | 41 | 46.1 | 115 | 239 | 107.2 | 225 | 437 |
| −12.2 | 10 | 50 | 48.9 | 120 | 248 | 110 | 230 | 446 |
| −9.4 | 15 | 59 | 51.6 | 125 | 257 | 112.8 | 235 | 455 |
| −6.7 | 20 | 68 | 54.4 | 130 | 266 | 115.6 | 240 | 464 |
| −3.9 | 25 | 77 | 57.1 | 135 | 275 | 118.2 | 245 | 473 |
| −1.1 | 30 | 86 | 60 | 140 | 284 | 120.9 | 250 | 482 |
| 1.7 | 35 | 95 | 62.7 | 145 | 293 | 123.7 | 255 | 491 |
| 4.4 | 40 | 104 | 65.5 | 150 | 302 | 126.5 | 260 | 500 |
| 7.2 | 45 | 113 | 68.3 | 155 | 311 | 129.3 | 265 | 509 |
| 10 | 50 | 122 | 71 | 160 | 320 | 132.2 | 270 | 518 |
| 12.8 | 55 | 131 | 73.8 | 165 | 329 | 135 | 275 | 527 |

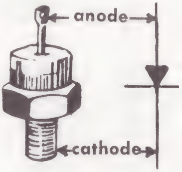
$°F = (9/5 \times °C) + 32$

$°C = 5/9\,(°F - 32)$

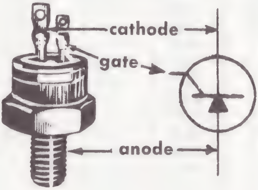
# DIMENSIONS, WEIGHT AND RESISTANCE OF PURE COPPER WIRE

| Gauge No. A.W.G. | Dia. In. | Area Circular Mils ($d^2$) 1 Mil = .001 In. | Lb. per 1000 Feet Bare Wire | Length Feet per Lb. | Resistance at 77°F. Ohms per 1000 Ft. |
|---|---|---|---|---|---|
| STRANDED | 1.151 | 1000000. | 3090. | .3235 | .0108 |
| | 1.029 | 800000. | 2470. | .4024 | .0135 |
| | .963 | 700000. | 2160. | .4628 | .0154 |
| | .891 | 600000. | 1850. | .5400 | .0180 |
| | .814 | 500000. | 1540. | .6488 | .0216 |
| | .726 | 400000. | 1240. | .8060 | .0270 |
| | .574 | 250000. | 772. | 1.30 | .0431 |
| 0000 | .4600 | 211600. | 640.5 | 1.56 | .0490 |
| 000 | .4096 | 167800. | 507.9 | 1.97 | .0618 |
| 00 | .3648 | 133100. | 402.8 | 2.48 | .0871 |
| 0 | .3249 | 105500. | 319.5 | 3.13 | .0983 |
| 1 | .2893 | 83690. | 253.3 | 3.95 | .1239 |
| 2 | .2576 | 66370. | 200.9 | 4.96 | .1563 |
| 3 | .2294 | 52630. | 159.3 | 6.28 | .1970 |
| 4 | .2043 | 41740. | 126.4 | 7.91 | .2485 |
| 5 | .1819 | 33100. | 100.2 | 9.98 | .3133 |
| 6 | .1620 | 26250. | 79.46 | 12.59 | .3951 |
| 7 | .1443 | 20820. | 63.02 | 15.87 | .4982 |
| 8 | .1285 | 16510. | 49.98 | 20.01 | .6282 |
| 9 | .1144 | 13090. | 39.63 | 25.23 | .7921 |
| 10 | .1019 | 10380 | 31.43 | 31.82 | .9989 |
| 11 | .09074 | 8234. | 24.92 | 40.12 | 1.260 |
| 12 | .08081 | 6530. | 19.77 | 50.59 | 1.588 |
| 13 | .07196 | 5178. | 15.68 | 63.80 | 2.003 |
| 14 | .06408 | 4107. | 12.43 | 80.44 | 2.525 |
| 15 | .05707 | 3257. | 9.86 | 101.4 | 3.184 |
| 16 | .05082 | 2583. | 7.82 | 127.9 | 4.016 |
| 17 | .04526 | 2048. | 6.20 | 161.3 | 5.064 |
| 18 | .04030 | 1624. | 4.92 | 203.4 | 6.385 |
| 19 | .03589 | 1288. | 3.90 | 256.5 | 8.051 |
| 20 | .03196 | 1022. | 3.09 | 323.4 | 10.15 |
| 21 | .02846 | 810.1 | 2.45 | 407.8 | 12.80 |
| 22 | .02535 | 642.4 | 1.95 | 514.2 | 16.14 |
| 23 | .02257 | 509.5 | 1.54 | 648.4 | 20.36 |
| 24 | .02010 | 404.0 | 1.22 | 817.7 | 25.67 |
| 25 | .01790 | 320.4 | .970 | 1031.0 | 32.37 |
| 26 | .01594 | 254.1 | .769 | 1300.0 | 40.81 |
| 27 | .01420 | 201.5 | .610 | 1639.0 | 51.47 |
| 28 | .01264 | 159.8 | .484 | 2067.0 | 64.90 |
| 29 | .01126 | 126.7 | .384 | 2607.0 | 81.83 |
| 30 | .01003 | 100.5 | .304 | 3287.0 | 103.2 |
| 31 | .00893 | 79.70 | .241 | 4145.0 | 130.1 |
| 32 | .00795 | 63.21 | .191 | 5227.0 | 164.1 |
| 33 | .00708 | 50.13 | .152 | 6591.0 | 206.9 |
| 34 | .00631 | 39.75 | .120 | 8310.0 | 260.9 |
| 35 | .00562 | 31.52 | .095 | 10480.0 | 329.0 |
| 36 | .00500 | 25.00 | .076 | 13210.0 | 414.8 |

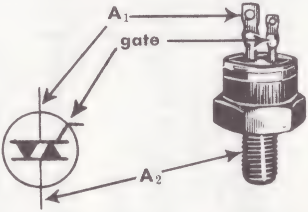
SILICON MEDIUM-CURRENT RECTIFIER



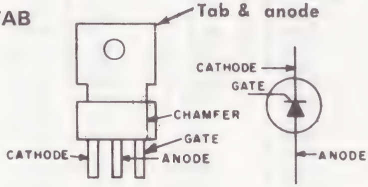

LOW CURRENT SCR



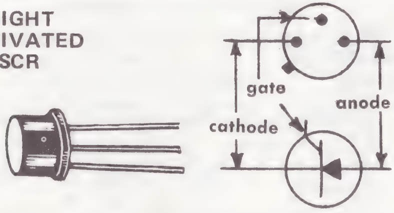

TRIAC



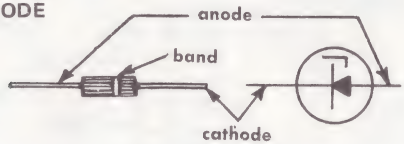

POWER-TAB SCR



LIGHT ACTIVATED SCR



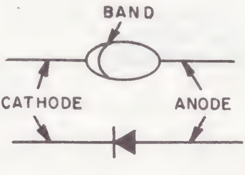

ZENER & SIGNAL DIODE




DIAC

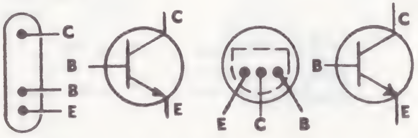
(no polarity)

SILICON RECTIFIER

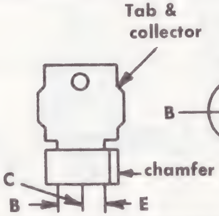


# TRANSISTOR SYMBOLS AND CONNECTIONS

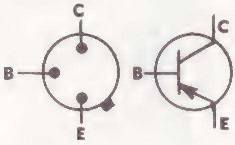
NPN
TRANSISTOR



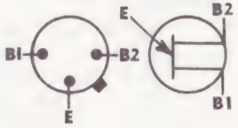

NPN
TRANSISTOR




PNP
TRANSISTOR



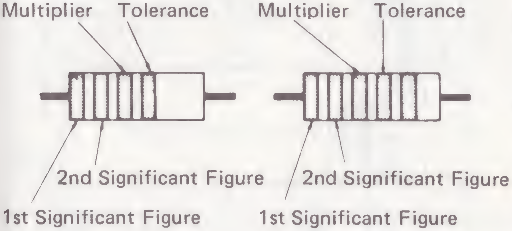

SILICON
UNIJUNCTION
TRANSISTOR



# RESISTOR COLOR CODES

| RESISTOR COLOR CODE | | | |
|---|---|---|---|
| **Color** | **1st & 2nd Significant Figures** | **Multiplier** | **Tolerance** |
| Black | 0 | 1 | — |
| Brown | 1 | 10 | ±1% |
| Red | 2 | 100 | ±2% |
| Orange | 3 | 1000 | ±3% |
| Yellow | 4 | 10000 | ±4% |
| Green | 5 | 100000 | — |
| Blue | 6 | 1000000 | — |
| Violet | 7 | 10000000 | — |
| Gray | 8 | 100000000 | — |
| White | 9 | — | — |
| Gold | — | 0.1 | ±5% |
| Silver | — | 0.01 | ±10% |
| No Color | — | — | ±20% |

### COLOR BAND SYSTEM




Resistors with Black Body Color are Composition. Non Insulated.

Resistors with Colored Bodies are Composition Insulated.

Wirewound Resistors have the 1st Digit Color Band Double Width.

## CAPACITOR COLOR CODES

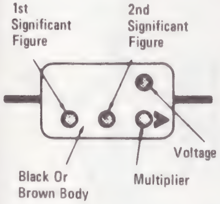
### MICA CAPACITOR COLOR CODE

| Color | Characteristic* | Capacitance: 1st & 2nd Significant Figures | Capacitance: Multiplier | Capacitance Tolerance | DC Working Voltage | Operating Temperature Range |
|---|---|---|---|---|---|---|
| Black | A (E1A) | 0 | 1 | ±20% (E1A) | | –55° to + 70°C (MIL) |
| Brown | B | 1 | 10 | ±1% | 100 (E1A) | |
| Red | C | 2 | 100 | ±2% | | –55° to + 85°C |
| Orange | D | 3 | 1000 | | 300 | |
| Yellow | E | 4 | 10000 (E1A) | | | –55° to + 125°C |
| Green | F | 5 | | ±5% | 500 | |
| Blue | | 6 | | | | –55° to +150°C (MIL) |
| Purple | | 7 | | | | |
| Gray | | 8 | | | | |
| White | | 9 | | | | |
| Gold | | | 0.1 | ±1/2% (E1A) | 1000 (E1A) | |
| Silver | | | 0.01 (E1A) | ±10% | | |

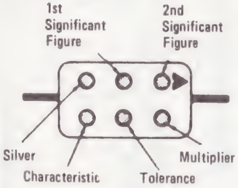
*Denotes specifications of design involving Q factors, temperature coefficients, and production test requirements.

†Or ±0.5 pf, whichever is greater. All others are specified tolerance or ±1.0 pf, whichever is greater.

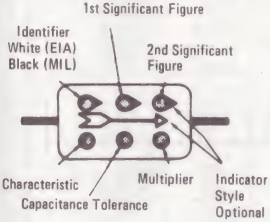
MOLDED FLAT PAPER CAPACITORS
(COMMERCIAL CODE)



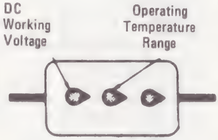

MOLDED FLAT PAPER CAPACITORS
(MILITARY CODE)




CURRENT EIA AND MILITARY COLOR CODE FOR MOLDED MICA CAPACITORS




A (FRONT)




B (REAR)

NOTES:

1. The multiplier is the factor by which the two significant figures are multiplied to yield the nominal capacitance.
2. "A" illustrates standard six-dot system used for "N" temperature range capacitors manufactured according to EIA Standard RS-153-A.
3. Drawings "A" and "B" combined illustrate standard nine-dot system used for "O" temperature range capacitors manufactured according to EIA Standard RS-153-A, and for all units manufactured according to Military Specification MIL-C-5C.

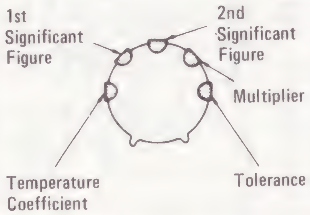
## CAPACITOR COLOR CODES (CONT'D.)

### CERAMIC CAPACITOR CODES (CAPACITANCE GIVEN IN PF)

| COLOR | DIGIT | MULTIPLIER | TOLERANCE | | TEMPERATURE COEFFICIENT PPM °C |
|---|---|---|---|---|---|
| | | | 10 PF OR LESS | OVER 10 PF | |
| Black | 0 | 1 | ±2.0 pf | ±20%* | 0 |
| Brown | 1 | 10 | ±0.1 pf | ±1% | -33 |
| Red | 2 | 100 | | ±2% | -75 |
| Orange | 3 | 1000 | ±0.25 pf | ±2.5%* | -150 |
| Yellow | 4 | 10000 | | | -220 |
| Green | 5 | | ±0.5 pf | ±5% | -330 |
| Blue | 6 | | | | -470 |
| Violet | 7 | | | | -750 |
| Gray | 8 | .01 | ±0.25pf* | | +30 |
| White | 9 | .1 | ±1.0 pf | ±10% | General Purpose Bypass & Coupling |
| Silver | | | | | |
| Gold | | | | | +100 (MIL) |

*EIA only. Ceramic Capacitor capacitor voltage ratings are standard 500 volts, for some manufacturers. 1000 volts for other manufacturers, unless otherwise specified.

### DISC CERAMICS (5-DOT SYSTEM)




### DISC CERAMICS (3-DOT SYSTEM)

# DECIMAL AND METRIC EQUIVALENTS OF COMMON FRACTIONS OF AN INCH

| Fraction | | Decimal | Mm | Fraction | | Decimal | Mm |
|---|---|---|---|---|---|---|---|
| | 1/64 | 0.01562 | 0.397 | | 33/64 | 0.51562 | 13.097 |
| 1/32 | | 0.03125 | 0.794 | 17/32 | | 0.53125 | 13.494 |
| | 3/64 | 0.04688 | 1.191 | | 35/64 | 0.54688 | 13.891 |
| 1/16 | | 0.06250 | 1.588 | 9/16 | | 0.56250 | 14.288 |
| | 5/64 | 0.07812 | 1.984 | | 37/64 | 0.57812 | 14.684 |
| 3/32 | | 0.09375 | 2.381 | 19/32 | | 0.59375 | 15.081 |
| | 7/64 | 0.10938 | 2.778 | | 39/64 | 0.60938 | 15.478 |
| 1/8 | | 0.12500 | 3.175 | 5/8 | | 0.62500 | 15.875 |
| | 9/64 | 0.14062 | 3.572 | | 41/64 | 0.64062 | 16.272 |
| 5/32 | | 0.15625 | 3.969 | 21/32 | | 0.65625 | 16.669 |
| | 11/64 | 0.17188 | 4.366 | | 43/64 | 0.67188 | 17.066 |
| 3/16 | | 0.18750 | 4.763 | 11/16 | | 0.68750 | 17.463 |
| | 13/64 | 0.20312 | 5.159 | | 45/64 | 0.70312 | 17.859 |
| 7/32 | | 0.21875 | 5.556 | 23/32 | | 0.71875 | 18.256 |
| | 15/64 | 0.23438 | 5.953 | | 47/64 | 0.73438 | 18.653 |
| 1/4 | | 0.25000 | 6.350 | 3/4 | | 0.75000 | 19.050 |
| | 17/64 | 0.26562 | 6.747 | | 49/64 | 0.76562 | 19.447 |
| 9/32 | | 0.28125 | 7.144 | 25/32 | | 0.78125 | 19.844 |
| | 19/64 | 0.29688 | 7.541 | | 51/64 | 0.79688 | 20.241 |
| 5/16 | | 0.31250 | 7.938 | 13/16 | | 0.81250 | 20.638 |
| | 21/64 | 0.32812 | 8.334 | | 53/64 | 0.82812 | 21.034 |
| 11/32 | | 0.34375 | 8.731 | 27/32 | | 0.84375 | 21.431 |
| | 23/64 | 0.35938 | 9.128 | | 55/64 | 0.85938 | 21.828 |
| 3/8 | | 0.37500 | 9.525 | 7/8 | | 0.87500 | 22.225 |
| | 25/64 | 0.39062 | 9.922 | | 57/64 | 0.89062 | 22.622 |
| 13/32 | | 0.40625 | 10.319 | 29/32 | | 0.90625 | 23.019 |
| | 27/64 | 0.42188 | 10.716 | | 59/64 | 0.92188 | 23.416 |
| 7/16 | | 0.43750 | 11.113 | 15/16 | | 0.93750 | 23.813 |
| | 29/64 | 0.45312 | 11.509 | | 61/64 | 0.95312 | 24.209 |
| 15/32 | | 0.46875 | 11.906 | 31/32 | | 0.96875 | 24.606 |
| | 31/64 | 0.48438 | 12.303 | | 63/64 | 0.98438 | 25.003 |
| 1/2 | | 0.50000 | 12.700 | 1/1 | | 1.00000 | 25.400 |

# NATURAL TRIGONOMETRIC FUNCTIONS

| Angle | Sin | Tan | Cot | Cos | Deg |
|---|---|---|---|---|---|
| 0 | 0.0000 | 0.0000 | ∞ | 1.0000 | 90 |
| 1 | 0.0175 | 0.0175 | 57.2900 | 0.9998 | 89 |
| 2 | 0.0349 | 0.0349 | 28.6363 | 0.9994 | 88 |
| 3 | 0.0523 | 0.0524 | 19.0811 | 0.9986 | 87 |
| 4 | 0.0698 | 0.0699 | 14.3007 | 0.9976 | 86 |
| 5 | 0.0872 | 0.0875 | 11.4300 | 0.9962 | 85 |
| 6 | 0.1045 | 0.1051 | 9.5144 | 0.9945 | 84 |
| 7 | 0.1219 | 0.1228 | 8.1443 | 0.9925 | 83 |
| 8 | 0.1392 | 0.1405 | 7.1154 | 0.9903 | 82 |
| 9 | 0.1564 | 0.1584 | 6.3138 | 0.9877 | 81 |
| 10 | 0.1736 | 0.1763 | 5.6713 | 0.9848 | 80 |
| 11 | 0.1908 | 0.1944 | 5.1446 | 0.9816 | 79 |
| 12 | 0.2079 | 0.2126 | 4.7046 | 0.9781 | 78 |
| 13 | 0.2250 | 0.2309 | 4.3315 | 0.9744 | 77 |
| 14 | 0.2419 | 0.2493 | 4.0108 | 0.9703 | 76 |
| 15 | 0.2588 | 0.2679 | 3.7321 | 0.9659 | 75 |
| 16 | 0.2756 | 0.2867 | 3.4874 | 0.9613 | 74 |
| 17 | 0.2924 | 0.3057 | 3.2709 | 0.9563 | 73 |
| 18 | 0.3090 | 0.3249 | 3.0777 | 0.9511 | 72 |
| 19 | 0.3256 | 0.3443 | 2.9042 | 0.9455 | 71 |
| 20 | 0.3420 | 0.3640 | 2.7475 | 0.9397 | 70 |
| 21 | 0.3584 | 0.3839 | 2.6051 | 0.9336 | 69 |
| 22 | 0.3746 | 0.4040 | 2.4751 | 0.9272 | 68 |
| 23 | 0.3907 | 0.4245 | 2.3559 | 0.9205 | 67 |
| 24 | 0.4067 | 0.4452 | 2.2460 | 0.9135 | 66 |
| 25 | 0.4226 | 0.4663 | 2.1445 | 0.9063 | 65 |
| 26 | 0.4384 | 0.4877 | 2.0503 | 0.8988 | 64 |
| 27 | 0.4540 | 0.5095 | 1.9626 | 0.8910 | 63 |
| 28 | 0.4695 | 0.5317 | 1.8807 | 0.8829 | 62 |
| 29 | 0.4848 | 0.5543 | 1.8040 | 0.8746 | 61 |
| 30 | 0.5000 | 0.5774 | 1.7321 | 0.8660 | 60 |
| 31 | 0.5150 | 0.6009 | 1.6643 | 0.8572 | 59 |
| 32 | 0.5299 | 0.6249 | 1.6003 | 0.8480 | 58 |
| 33 | 0.5446 | 0.6494 | 1.5399 | 0.8387 | 57 |
| 34 | 0.5592 | 0.6745 | 1.4826 | 0.8290 | 56 |
| 35 | 0:5736 | 0.7002 | 1.4281 | 0.8192 | 55 |
| 36 | 0.5878 | 0.7265 | 1.3764 | 0.8090 | 54 |
| 37 | 0.6018 | 0.7536 | 1.3270 | 0.7986 | 53 |
| 38 | 0.6157 | 0.7813 | 1.2799 | 0.7880 | 52 |
| 39 | 0.6293 | 0.8098 | 1.2349 | 0.7771 | 51 |
| 40 | 0.6428 | 0.8391 | 1.1918 | 0.7660 | 50 |
| 41 | 0.6561 | 0.8693 | 1.1504 | 0.7547 | 49 |
| 42 | 0.6691 | 0.9004 | 1.1106 | 0.7431 | 48 |
| 43 | 0.6820 | 0.9325 | 1.0724 | 0.7314 | 47 |
| 44 | 0.6947 | 0.9657 | 1.0355 | 0.7193 | 46 |
| 45 | 0.7071 | 1.0000 | 1.0000 | 0.7071 | 45 |
| Deg | Cos | Cot | Tan | Sin | Angle |

# CONVERSION FACTORS

## AREA

1 sq. mile = 640 acres
1 acre = 4840 sq. yards
1 acre = 43,560 sq. ft.
1 sq. foot = 144 sq. inches
1 sq. yard = .836 sq. meters
1 sq. meter = 1.196 sq. yards
1 sq. ft. = .0929 sq. meters
1 cir. mil = $7.854 \times 10^{-7}$ sq. inch.
1 cir. mil = .7854 sq. mils
1 sq. mil = 1.273 cir. mils
1 sq. inch = 6.452 sq. cm.
1 sq. cm. = .155 sq. inch

## ANGLE

1 quadrant = 90 degrees
1 quadrant = 1.57 radians
1 radian = 57.3 degrees
1 degree = .0175 radian
1 minute = .01667 degree
1 minute = $2.9 \times 10^{-4}$ radian

## LENGTH

1 mile = 5280 feet
1 mile = 1.609 kilometers
1 kilometer = .621 miles
1 yard = .9144 meters
1 meter = 3.28 feet
1 meter = 39.37 inches
1 meter = 1.094 yards
1 foot = 12 inches
1 foot = .3048 meters
1 inch = 2.54 centimeters
1 centimeter = .394 inch
1 fathom - 6 feet
1 rod = 5½ yards

## WEIGHT

1 short ton = 2000 pounds
1 short ton = 907.2 kilograms
1 kilogram = 2.205 pounds
1 pound = 453.6 grams
1 ounce = 28.35 grams
1 gram = .0353 ounces

## DRY VOLUME

1 cu. meter = 1.308 cu. yards
1 cu. yard = .7646 cu. meters
1 cu. meter = 35.31 cu. feet
1 cu. foot = .0283 cu. meters

## LIQUID VOLUME

1 U.S. gallon = 3.785 liters
1 liters = .2642 U.S. gallons
1 U.S. quart = .9463 liters
1 liter = 1.057 U.S. quarts

## POWER

1 horsepower = 746 watts
1 horsepower = 33000 ft-lbs/min
1 horsepower = 550 ft-lbs/sec.
1 BTU/hour = .293 watts
1 BTU = 252 gram-calories
1 BTU = 778.3 ft-lbs.

## PROPERTIES OF VARIOUS

| Material | Resistivity $10^{-6}$ OHM - cm. near $20^{o}$C. | Temp. Coeff. of Resistivity near $20^{o}$C/$^{o}$C |
|---|---|---|
| Aluminum – pure | 2.65 | 0.0043 |
| – conductor | 2.80 | – |
| Beryllium | 4.0 | – |
| Bismuth | 106.8 * | 0.004 |
| Brass, yellow (65 Cu, 35 Zn) | 6.4 | 0.002 |
| Bronze, commercial (90 Cu, 10 Zn) | 3.9 | 0.0019 |
| Cadmium – pure | 6.83 * | 0.0042 |
| Chromium | 13.0 | 0.003 |
| Cobalt | 6.24 | 0.006 |
| Constantan (55 Cu, 45 Ni) | 50.0 | ±0.00002 |
| Copper, annealed (1ACS) | 1.724 | 0.0039 |
| hard drawn | 1.776 | 0.0038 |
| Germanium | 46.0 ** | – |
| Gold | 2.35 | 0.004 |
| Inconel (76 Ni, 16 Cr, 8 Fe) | 98.1 | 0.000001 |
| Indium | 8.37 | 0.005 |
| Invar (64 Fe, 36 Ni) | 80.0 | 0.0012 |
| Iron, pure | 9.71 | 0.0065 |
| Lead | 20.65 | 0.0034 |
| Magnesium | 4.45 | 0.0037 |
| Mercury | 96.0 | 0.0009 |
| Molybdenum | 5.7 | 0.005 |
| Monel (67 Ni, 30 Cu) | 48.2 | 0.0023 |
| Nichrome (80 Ni, 20 Cr) | 108.0 | 0.0001 |
| Nickel (99.4 Ni) | 9.5 | 0.005 |
| Niobium | 12.5 | 0.004 |
| Palladium | 10.8 | 0.0037 |
| Phosphor – Bronze (95 Cu, 5 Sn) | 11.0 | – |
| Platinum | 10.64 | 0.00393 |
| Silicon | $10^{5}$ ** | – |
| Silver | 1.59 | 0.0041 |
| Steel, Carbon (.4-.5 C, Bal. Fe) | 7-12 | – |
| Steel, Silicon (3 Si, Bal. Fe) | 50 | – |
| Steel, Stainless, 304 | 72 | – |
| Steel, Stainless, 347 | 73 | – |
| Steel, Stainless, 410 | 57 | – |
| Tantalum | 12.45 | 0.0038 |
| Thorium | 14.0 | 0.0038 |
| Tin | 12.0 | 0.0046 |
| Titanium | 42.0 | 0.006 |
| Tungsten | 5.65 | 0.0045 |
| Uranium | 30.0 | – |
| Zinc | 5.92 | 0.0042 |
| Zirconium | 40.0 | 0.0044 |

*at $0^{o}$C
**OHM - cm.

# METALS AND ALLOYS

| Weight Lbs./In.$^3$ | Thermal Cond. 20°C w/cm-°C | Thermal Expansion near 20°C ($x10^{-6}$/°C) | Melting Point, °C |
|---|---|---|---|
| 0.0975 | 2.22 | 23.6 | 660 |
| 0.0975 | 2.34 | 23.6 | 657 |
| 0.0668 | 1.46 | 11.6 | 1277 |
| 0.354 | 0.08 | 13.3 | 271 |
| 0.306 | 1.17 | 20.3 | 930 |
| 0.317 | 1.88 | 18.4 | 1045 |
| 0.312 | 0.92 | 29.8 | 321 |
| 0.259 | 0.67 | 6.2 | 1875 |
| 0.319 | 0.69 | 13.8 | 1495 |
| 0.321 | 0.21 | 14.9 | 1290 |
| 0.3223 | 3.91 | 16.8 | 1083 |
| 0.322 | – | – | 1083 |
| 0.192 | 0.59 | 5.75 | 937 |
| 0.6973 | 2.96 | 14.2 | 1063 |
| 0.307 | 0.15 | 11.5 | 1425 |
| 0.264 | 0.24 | 33.0 | 156 |
| 0.288 | 0.11 | – | 1425 |
| 0.284 | 0.75 | 11.8 | 1536 |
| 0.410 | 0.35 | 29.3 | 327 |
| 0.063 | 1.53 | 27.1 | 650 |
| 0.376 | 0.08 | – | -39 |
| 0.3685 | 1.42 | 4.9 | 2610 |
| 0.319 | 0.26 | 14.0 | 1325 |
| 0.303 | 0.134 | 13.0 | 1400 |
| 0.321 | 0.61 | 13.3 | 1450 |
| 0.310 | 0.52 | 7.3 | 2468 |
| 0.435 | 0.70 | 11.8 | 1552 |
| 0.317 | 0.71 | 17.8 | 1000 |
| 0.775 | 0.69 | 8.9 | 1769 |
| 0.0841 | 1.25 | 2.5 | 1420 |
| 0.3793 | 4.18 | 19.7 | 961 |
| 0.284 | 0.5 | 11.0 | 1480 |
| 0.276 | 0.18 | 12.0 | 1475 |
| 0.286 | 0.15 | 17.0 | $>$ 1400 |
| 0.285 | 0.16 | 16.3 | $>$ 1400 |
| 0.280 | 0.24 | 11.0 | $>$ 1480 |
| 0.600 | 0.54 | 6.6 | 3000 |
| 0.421 | 0.37 | 12.5 | 1750 |
| 0.263 | 0.63 | 23.0 | 232 |
| 0.163 | 0.41 | 8.4 | 1670 |
| 0.6973 | 1.67 | 4.6 | 3410 |
| 0.683 | 0.27 | 7-14 | 1132 |
| 0.258 | 1.10 | 33.0 | 419 |
| 0.234 | 0.21 | 5.8 | 1852 |

# SAVE A LIFE

First aid-trained people do not usually have the experience, training, and essential equipment to distinguish whether or not lack of breathing is a result of disease or accident. Therefore, artificial respiration should be started at the earliest possible moment.

Careful medical experiments have shown conclusively that the rescue breathing technique is the most effective means for administering artificial respiration. The only equipment necessary to perform rescue breathing is carried with you at all times—your hands, your mouth and your repetitive breathing.

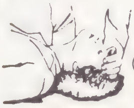
The mouth-to-mouth (Rescue Breathing) technique has the advantage of providing pressure to inflate the victim's lungs immediately. It also enables the rescuer to obtain more accurate information on the volume, pressure, and timing of efforts needed to inflate the victim's lungs than are afforded by other methods.

When a person is unconscious and not breathing, the base of the tongue tends to press against and block the upper air passageway. The procedures described below should provide for an open air passageway when a lone rescuer must perform artificial respiration.

**A. Mouth-to-Mouth (rescue breathing) method of artificial respiration**

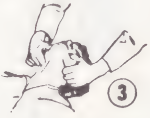
If there is foreign matter visible in the mouth, wipe it out quickly with your fingers or a cloth wrapped around your fingers.

1. Tilt the head back so the chin is pointing upward (Fig. 1). Pull or push the jaw into a jutting-out position (Fig. 2 and Fig. 3).



1

2



3

## SAVE A LIFE –
### Continued

These maneuvers should relieve obstruction of the airway by moving the base of the tongue away from the back of the throat.

2. Open your mouth wide and place it tightly over the victim's mouth. At the same time pinch the victim's nostrils shut (Fig. 4) or close the nostrils with your cheek (Fig. 5). Or close the victim's mouth and place your mouth over the nose (Fig. 6). Blow into the victim's mouth or nose. (Air may be blown through the victim's teeth, even though they may be clenched.)

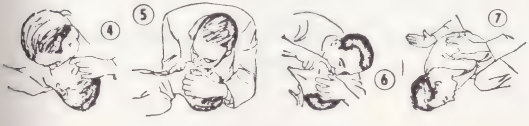
The first blowing efforts should determine whether or not obstruction exists.

3. Remove your mouth, turn your head to the side, and listen for the return rush of air that indicates air exchange. Repeat the blowing effort.

For an adult, blow vigorously at the rate of about 12 breaths per minute. For a child, take relatively shallow breaths appropriate for the child's size at the rate of about 20 per minute.

4. If you are not getting air exchange, recheck the head and jaw position (Fig. 1 or Fig. 2 and Fig. 3). If you still do not get air exchange, quickly turn the victim on his side and administer several sharp blows between the shoulder blades in the hope of dislodging foreign matter (Fig. 7).

Again sweep your fingers through the victim's mouth to remove foreign matter.



# GLOSSARY OF TERMS

**Horsepower** — A unit for measuring the power of motors. One horsepower equals 33,000 foot-pounds of work per minute.

**Foot-Pound** — The amount of energy required to raise a one-pound weight a distance of one-foot.

**Torque** — Rotating force produced by a motor.

**Units of Torque** — Pound-feet, ounce-inches, ounce-feet

**Full Load Torque** — Torque required to produce rated horsepower at full load speed.

**Breakdown Torque** — Maximum torque a motor will produce. Often times referred to as Pull-Out Torque, or Maximum Torque.

**Starting Torque** — Torque produced by a motor at rest when power is applied.

**Synchronous Speed** — Maximum speed for an alternating — current motor.

$$\text{Equal to } \frac{\text{Frequency} \times 120}{\text{poles}}$$

**Full Load Speed** — Speed at which rated horsepower is developed.

## GLOSSARY OF TERMS—Continued

| | |
|---|---|
| **Slip —** | Percentage difference between synchronous and operating speeds. |
| **Poles —** | The number of magnetic poles set up inside the motor by the placement and connection of the windings. |
| **Stator —** | Stationary part of a motor. |
| **Rotor —** | Rotating element of an induction machine. |
| **Armature —** | Rotating element of a machine requiring a commutator. |
| **Insulation —** | Non-conducting materials separating the current—carrying parts from each other or from the core. |
| **Mush Coil —** | Coil made with round wire. |
| **Form Coil —** | Coil made with rectangular or square wires. |
| **Ambient Temperature —** | The temperature of the surrounding cooling medium. |
| **Rated Temperature Rise —** | The permissible rise in temperature above ambient when operating under load. |
| **Hertz —** | Preferred terminology for "Cycles per Second." |

# TAP DRILLS AND CLEARANCE DRILLS FOR MACHINE SCREWS

| Screw Size | Coarse Thread TPI | Coarse Thread Drill | Fine Thread TPI | Fine Thread Drill | Clearance Drill | Body Dia. |
|---|---|---|---|---|---|---|
| 4 | 40 | 43 | 48 | 42 | 32 | .112 |
| 5 | 40 | 38 | 44 | 37 | 30 | .125 |
| 6 | 32 | 36 | 40 | 33 | 27 | .138 |
| 8 | 32 | 29 | 36 | 29 | 18 | .164 |
| 10 | 24 | 25 | 32 | 21 | 9 | .190 |
| 12 | 24 | 16 | 28 | 14 | 2 | .216 |
| 14 | 20 | 10 | 24 | 7 | D | .242 |
| 1/4 | 20 | 7 | 28 | 3 | F | .250 |
| 5/16 | 18 | F | 24 | 1 | P | .3125 |
| 3/8 | 16 | 5/16 | 24 | Q | W | .375 |
| 7/16 | 14 | U | 20 | 25/64 | 29/64 | .4375 |
| 1/2 | 13 | 27/64 | 20 | 29/64 | 33/64 | .500 |
| 9/16 | 12 | 31/64 | 18 | 33/64 | 37/64 | .5625 |
| 5/8 | 11 | 17/32 | 18 | 37/64 | 41/64 | .625 |
| 3/4 | 10 | 21/32 | 16 | 11/16 | 49/64 | .750 |

# NOTES

# NOTES

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